FACTORS AFFECTING PREGNANCY RATE IN CROSSBRED BEEF COWS ON A LARGE CENTRAL FLORIDA RANCH

By

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Abstract of Dissertation Presented to the Graduate School
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FACTORS AFFECTING PREGNANCY RATE IN CROSSBRED BEEF COWS ON A LARGE CENTRAL FLORIDA RANCH

By

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Factors affecting pregnancy rate (PR) and body condition score (BCS) were studied in 21,289 lactating cows on a large central Florida ranch. The mean PR was 77.2%. Breed types (BT) included Brangus, Braford, Charbray, and Brahman. Cow age groups (CAG) were 3-yr-olds, 4-yr-olds, 5- and 6-yr-olds, 7- and 8-yr-olds, 9- and 10-yr-olds, 11- and 12-yr-olds, and 13-yr-old and older. The PR was affected ($P < .02$) by BCS x CAG, BCS x MU, MU x CAG, and BT x CAG. PR were 42.3, 76.4, 92.7, and 96.9% for BCS 3, 4, 5, and 6 cows, respectively. The PR ranged from 81 to 72.3% for CAG 3-yr-olds and 11- and 12-yr-olds respectively. The PR declined in BCS 3 and 4 cows after age 8 but remained the same for all CAG in BCS 5 and 6. The PR for Brangus and Braford tended to be constant across all CAG but tended to be lower in older CAG for Charbray and in younger and older CAG for Brahman.

Within BCS 4 cows, PR was affected (P < .0003) by BT, MU, CAG, and the MU x CAG interaction. Brangus and Braford cows had PR of 81.7 and 79.5%, respectively, which were higher than the Brahman PR of 68.7%. The Charbray PR was 75.9% which did not differ from other BT. The PR was highest in the 5- through 8-yr-old cows. The mean BCS was 4.2 and BCS was affected by BT, MU, CAG, and the interactions of MU x CAG and BT x CAG. Mean BCS peaked in 5- through 8-yr-old cows and declined with increased or decreased age. The lowest BCS was 3.9 in 13-yr-old and older CAG.

Additional factors of pregnancy history, hair length score, and coat color were studied in a 4,071 subset. MU and BCS were deleted from the model. Mean PR and BCS was 72.1% and 3.8, respectively. Pregnancy history and coat color did not affect PR. The PR and BCS were 80.1% and 4.1, 72.3% and 3.9, and 61.9% and 3.6 for cows with short, medium, and long hair length scores, respectively.

INTRODUCTION

The state of Florida ranks tenth among the states in number of cattle, with the overwhelming majority of the cattle being owned by cow-calf operations. Most of these cows are located in central and south Florida. Ranches in this area tend to have relatively large numbers of cows, and thus, have different management challenges than the more typical producer with a small or medium size cow herd. Also, the subtropical climate and *Bos indicus* influence in the cattle present distinct challenges to profitable ranching.

To a great degree, the level of profitability for a cow-calf operation equates to the level of reproductive performance in the cow herd. While growth and quality influence performance and price received at the market, the relatively small improvements in price received for better performing or higher quality calves is far overshadowed by the failure to receive any income from a cow which fails to have a calf. High pregnancy rates are necessary for profitable cow-calf operations.

Solid data are lacking, but it is commonly assumed that the average pregnancy rate for Florida is lower than the national average. Also, the large cow-calf operations in central and southern Florida typically have low calf crop percentages. Identification of the factors which result in lower reproductive performance in Florida, and more specifically on large cow-calf operations in central and southern Florida, offers to these operations the opportunity to increase profits.

The primary objective of this study was to determine the effects of various factors on pregnancy rate on a large central Florida ranch. Since cow body condition is commonly associated with poorer reproductive performance, a second objective was to determine the effects of other factors on cow body condition. Phase 1 of this study examines the effects of various factors on both pregnancy rate and cow condition. Phase 2 consisted of a subset of the cows included in Phase 1 on which additional data were collected. The major objective of Phase 2 was to determine the effects of previous pregnancy history, hair length, and coat color on pregnancy rate and coat color.

REVIEW OF LITERATURE

Pregnancy rate in Florida has been demonstrated to be very low. Using data collected in the 5 yr period from 1953 through 1957 and including 10,170 cows from both Experiment Station and private herds, Warnick et al. (1969) reported a pregnancy rate of 70.9% . They concluded that, since certain herds had good reproductive rates, adequate reproductive levels could be achieved statewide. They reported that factors which affected pregnancy rate were lactational status, age of dam, breed, year, and location.

Body Condition Score

Variations in fatness or body condition in beef cows influence reproductive efficiency. Body condition score (BCS) is a subjective scoring system developed to rate cows according to condition or fatness (Herd and Sprott, 1986). Even though BCS is a subjective score, it has been reported to predict body energy levels. Dunn et al. (1983) reported that BCS was highly correlated (.77) with percent carcass fat, whereas live weight and weight to height ratio displayed lower correlations (.48 and .56 respectively). Similarly, Wagner et al. (1988) reported that 82% of the variation in total carcass energy could be accounted for by variations in BCS. Only 60% of the total carcass energy was accounted for by live weight and 64% by weight to height ratio. Conversely, Houghton et al. (1990), using a different BCS system, found that BCS and live weight were equally correlated (.62) with percent carcass lipids, while weight to height ratio had a slightly higher correlation (.68). The required weight change to increase one BCS unit was 32 kg in cows with an average BCS of 3.9 and weighing 358 kg (Menedez, 1971).

Cows with low BCS have lower pregnancy rates than cows with higher BCS (Richards et al.,1986; Selk et al., 1988). In a previous study conducted at Deseret Ranches of Florida, pregnancy rates after a 120 d breeding period were 23, 51, 73, 86 and 95% for BCS 2, 3, 4, 5, and 6 cows respectively (Wiltbank, 1991). A similar effect of BCS on pregnancy rates was noted in primiparous cows (Sprott et al., 1978; Butler et al., 1979; Wetterman et al., 1986).

Selk et al. (1988) concluded that pregnancy rates could be more accurately predicted by BCS at pre-calving or start of breeding season than by changes between live body weights taken pre-calving, at calving, and during the breeding season. Whitman (1975) found the postpartum interval to estrus (PPI) increased as BCS decreased. He reported that 91% of the cows with a good BCS showed estrus by 60 d postpartum regardless of positive or negative weight changes before or after parturition. In contrast, Rutter and Randel (1984) reported that cows with a good BCS at parturition and losing body condition had a longer PPI than those which maintained body condition. Cows in their study which lost BCS after calving had a 60 d average PPI compared to a 31.7 d average PPI for cows which maintained BCS. Richards et al. (1986) reported that the average PPI was 12 d longer for cows calving with a BCS of 4 compared to cows calving with a BCS of 5. Houghton et al. (1990) reported a PPI of 88.5 d in thin cows. This was 28 to 58 d longer than the PPI observed in cows in moderate or good condition.

Conflicting data are reported on the effect of BCS on percentage of cows becoming pregnant at first service. Whitman (1975) concluded that once estrus was achieved, neither weight change nor BCS affected the likelihood of pregnancy. Similarly, Selk et al. (1985) reported that BCS at calving had no influence on first service pregnancy rate. A conflicting report (Houghton et al., 1990) showed that very fleshy cows had a 29% reduction in first service pregnancy rate when compared with thinner cows. No significant differences were observed between moderate and thin conditioned cows. However, these data are suspect because, as the authors noted, the first service conception rates observed in the thin and moderate condition cows were unusually high (80 to 100%), while those reported in the fleshy cow were more typical (67 to 79%).

Age of Cow

Age of cow at the time of breeding has a pronounced effect on reproduction in lactating cows. Frequently, a decline in pregnancy rates in both younger and older cows has been reported. Lindley et al. (1958) reported reproductive performance declined rapidly after 10 yr of age in Hereford cows. In a study of lactating Brahman cows located in Florida, calving rates increased with age until 5 yr of age (Peacock et al., 1976). The calving rate among 3, 4 and 5-yr-old lactating cows increased from 49.5% for the 3-yr-olds to 68.2% and 81.6% for the 4 and 5-yr-old cows. The calving rate was relatively constant (78.7%) in cows 6 to 12 yr of age but declined to 68% in cows 13 to 17 yr of age. Similarly, data also collected in Florida by Reynolds (1990) showed that calving percentages were 38.7 and 54.5% in cows bred when lactating and 3 and 4-yr-old respectively. The calving percentage continued upward and peaked at 76.8% in 7-yr-old cows. Somewhat lower calving percentages were observed in cows 8 to 10 yr of age (70.3%) and 11 to 12 year of age (69.8%), while pregnancy rate declined to 63.5% in cows 13 to 18 yr of age. Neville et al. (1990) reported that the average number of calves produced per cow during the six preceding calving periods decreased as the age of the cow increased from 9 to 12 yr of age. The average numbers of calves produced per cow in the six preceding calving periods were 5.20, 5.07, 4.79 and 4.81 for the 9, 10, 11 and 12 yr olds respectively.

Breed

There is a lack of agreement among published reports on the effects of breed of dam on pregnancy rates. Research conducted in Florida by Peacock et al. (1971), with straightbred and reciprocal crosses of Brahman and Shorthorn cattle, indicated that significant differences existed in pregnancy rates among the breed groups. Average pregnancy rates for the Brahman and Shorthorn cows were 71% and 64% respectively, whereas the average pregnancy rate for the Brahman x Shorthorn crossbred groups was 77%. Similarly, Reynolds (1960), using data gathered in Florida, also reported a significant difference in calving percentage among breed groups, with pureblood Brahman cows exceeding Shorthorn cows in calving percentage (69.5% and 62.6% respectively). The calving rate of the Brahman x Shorthorn F^1 cows was significantly higher (84.9%) than that of the straightbreds. The author indicated that the increase in calving rate of the Brahman x Shorthorn F^1 cows over the average of the straightbred breeds was probably due to hybrid vigor. Other reports (Cartwright, 1973; Reynolds et al., 1979; Reynolds et al., 1986) also indicated differences among breeds and advantages for crossbred cows over straightbreds for pregnancy rates.

Contrasting results were reported by Peacock et al. (1977) who found no significant difference in pregnancy rate due to breed of dam when comparing Angus, Brahman and Charolais cattle. Other reports (Peacock et al., 1979; Bailey and Moore, 1980; Comerford et al., 1987) agreed with these findings.

Williams et al. (1991) reported that Brahman direct additive effects decreased calving rate. The Brahman direct additive effects on calving rate were 12.7% lower ($P < .05$) than the average direct additive effects of the Angus, Charolais, and Hereford breeds. The Brahman maternal heterotic effect on calving rate, when the Brahman was crossed with these three breeds, was large. The average calving rate for the three crosses involving Brahman was 15.3% greater than the average calving rate for the straightbreds.

Pasture

Quality of forage in Florida has been reported to influence reproductive performance. Reynolds (1960) reported differences of 19.5% between the poorest and best pastures for calving percentage in lactating cows. The lowest calving percentage (50.9%) was noted for lactating cows grazing unimproved flatwoods areas (native pastures), where herbage consisted principally of native species and carpet grass. The highest calving percentages for lactating cows were obtained on the clover-grass improved combination pastures which were either irrigated (70.1%) or where supplemental feed was provided (70.4%).

A significant pasture x age of cow interaction was also observed for calving percentage. Calving percentages were low in lactating 3-yr-old and 13 to 18-yr-old cows when maintained on native pasture (unadjusted calving rates of 14 and 36% respectively). Cows of the same age group maintained on irrigated clover-grass improved pasture had unadjusted calving rates of 75 and 100% respectively. Calving percentages in the 5 to 10-yr-old lactating cows were 54.5% for those grazing native pasture and 83.3% for those maintained on irrigated cover-grass improved pasture. In all age groups, the calving percentages were higher on the improved pastures; however, the improvement due to the use of improved pastures was much greater in the youngest (3-yr-old) and oldest (13 to 18-yr-old) age groups.

Peacock et al. (1971) also reported a significant pasture effect on pregnancy percentages with pregnancy rates of 81, 64 and 76% respectively, for cattle grazing irrigated clover-grass improved pastures, native pastures, and a combination native-improved pastures. A significant pasture x breed group interaction was also demonstrated for pregnancy rate. The straightbred groups responded differently than crossbred cattle to the better nutrition supplied by the improved pastures. The heterosis level for pregnancy rate of cows grazing native pastures was 9.8%, whereas it was 19.0% when cows were grazed on improved pastures.

Previous Pregnancy History

Little work has been done to determine the subsequent lifetime pregnancy rates of cows that failed to produce a calf one year, but become pregnant during the next breeding period. Neville et al. (1990) suggested that physically sound, nonpregnant cows should be considered for subsequent breeding. In his study, cows open one year bred similar to pregnant cows in the next breeding season, they produced a heavier calf, were cheaper to maintain, and had less calving difficulty than heifers. However, his work only considered the pregnancy rate obtained during the next year when the cow was nonlactating. Similarly, Turman et al. (1963) concluded, based on data drawn from the lifetime reproductive performance of a Hereford herd, that most nonpregnant cows would subsequently have calved annually through 10 yr of age. Hence they concluded that culling of nonpregnant cows would be relatively ineffective in improving subsequent calving percentages. On the other hand, Koger (1967) suggested that nonpregnant cows should be culled, and he gave as supporting evidence improvements in pregnancy rates obtained when such culling occurred. No data were presented to establish the subsequent lifetime reproductive performance of individual animals after failing to produce a calf one year.

Thermo-regulation: Coat Color and Hair Length

The ability of an animal to efficiently dissipate metabolic heat is important for maintenance of a constant body temperature. Heat exchange from the animal to the environment is accomplished in two steps. The first step is transfer of excessive internal heat from the central organs to the skin. The second step is accomplished by either evaporation through sweating or heat loss by convection from the skin to the adjacent air. Some additional heat is lost by evaporation via respiration (Finch, 1986).

Resistance to the transfer of heat from internal organs to the skin is dependent on the difference in temperatures between the skin and the internal body (Finch, 1985). She reported that when skin temperature approaches internal temperature the resistance to heat transfer is high and body temperatures will rise. *Bos indicus* cattle have been reported to lower this resistance to internal heat transfer; thus, internal heat can be moved to the surface of the skin at higher ambient temperatures in *Bos indicus* than in *Bos taurus* cattle (Finch, 1985).

Elevated internal body temperatures as determined by rectal temperatures have been associated with reduced reproductive performance in beef cows (Bond and McDowell, 1972; Turner, 1982). The suppression of calving percentage was similar at the same rectal temperatures in *Bos indicus* and *Bos taurus* cattle. The mean rectal temperature at elevated ambient temperatures is typically higher in *Bos taurus* than in *Bos indicus* cattle, and therefore, overall fertility is suppressed more in the *Bos taurus* (Turner, 1982).

A longer hair coat decreases both evaporation rate and convection heat losses and increases internal temperatures (Finch, 1986). She indicated that evaporation rates are determined by the relative humidity of the air immediately adjacent to the skin. Finch (1985) reported that sweating rate increased linearly with air temperature in both *Bos taurus* and *Bos indicus* cattle; however, increasing absolute humidity levels resulted in decreases in the sweating rate in *Bos taurus* cattle, whereas there was no negative effect of humidity on the sweating rate in *Bos indicus* cattle. The author concluded that reduction in sweating and thus, evaporation in the *Bos taurus* was a result of trapping water vapor in the air space between the hairs. The resulting elevated humidity within the coat area reduced the vapor pressure gradient between the skin and adjacent area and impeded evaporation. The author also concluded that heat transference by convection was impeded by the insulation effect of wooly, deep hair coats.

The above conclusions have been supported by trials showing lowered skin and rectal temperatures and better gains during the summer months in calves whose coats were clipped (Bianca, 1959; Turner, 1962). Australian workers concluded that coat hair length was influenced by seasonal variation, age, sex, nutrition, breed, and genetics. Repeatability of a coat hair length score was .60 over intervals of up to 17 mo, and the heritability estimate for the coat score was .63 (Turner and Schleger, 1960). In contrast, Canadian workers, Gilbert and Bailey (1991) found that hair type under cold conditions was moderately heritable (.24) in Angus and Hereford cattle and had no correlations with weight gains.

The effect of coat color on skin and body temperatures has also been examined. Varying absorption rates of solar radiation have been shown to effect skin temperature (Finch, 1986). The author concluded that increases in skin temperature were greater for dark than light-colored animals. The effects of this increase in skin temperature on internal body temperature are breed related and are associated with hair coat type among breeds (Finch, 1986). When dark red and white Shorthorn cattle were exposed to periods of strong sunshine, no increase was noted in rectal and skin temperatures for the white coated animals. On the other hand, increases in both skin and rectal temperatures were observed in the red-coated Shorthorns. Red Brahman cattle under the same conditions showed an increase in skin temperatures but no changes in body temperatures. In response to small shifts in internal temperatures, greater increases in sweating rates were noted in the Brahman cattle. Further, the longer hair of the Shorthorn cattle decreased both evaporation and convection heat losses (Finch et al., 1984). Work done in Arizona showed that reproductive performance in Holstein cattle during the summer months was poorer in predominately black cows than in cows with mostly white coat color (King et al., 1988).

In summary, long haired animals experience increased skin and body temperatures and poorer performance with increases in ambient temperatures. Darker coat color causes increased skin temperatures in all cattle but increased internal body temperatures and decreased performance are noted in only those animals with long hair.

PHASE 1
EFFECTS OF BODY CONDITION SCORE, COW AGE, BREED TYPE AND MANAGEMENT UNIT ON PREGNANCY RATE

Materials and Methods

Ranch and Management Units

Data for this study were collected at Deseret Ranches of Florida in the fall of 1985. Deseret Ranches is a 121,408 ha cow-calf operation owned by the Church of Jesus Christ of Latter-Day Saints and is located in Brevard, Osceola, and Orange counties in east central Florida. Approximately half the Ranch is in improved pastures of various forage types, with Pensacola bahiagrass (*Paspalum notatum*) being the most prevalent species. Additionally, sizable areas of other introduced forages also exist, among these forages are Pangola digitgrass (*Digitaria decumbens*), various bermudagrass varieties (*Cynodon dactylon*), limpograss (*Hemarthria altissima*) and white clover (*Trifolium repens*). The unimproved portion of the ranch includes large tracts of flatwoods soils with native vegetation (pine, palmetto, and wiregrass areas) and sizable areas of the St. John's River Marsh (sawgrass and maidencane areas). Many oak and cabbage palm hammocks, as well as hardwood and cypress swamps, are well interspersed throughout both the improved and unimproved areas. While most of the ranch is composed of the typical central Florida pine and palmetto flatwoods soils (spodosols), sizable areas of entisols and histosols (soil types) are also represented. The average annual rainfall is 1,400 mm, with the heaviest precipitation typically occurring in the June through September period. During this period there is a 50% chance of measurable rain on any given day. About 65% of the annual rainfall occurs during these months, with the balance being almost evenly distributed over the rest of the year. Rainfall at the ranch in 1985 was about 1,220 mm.

Data were collected at each of the 10 cattle units that maintained mature cow herds. Each unit comprised a distinct management unit, with a foreman who had authority to make many operational decisions. Consequently, differences in units existed not only due to physical variations (cow breeds, soil, forage types, etc.) but also due to the individual foremen's management decisions. Mature cattle seldom were transferred from one unit to another. Table 1 shows the total area, number of cows, improved pasture per cow, and 1985 average weaning weight for each of the management units. A brief description of the units follows.

> Unit 2. Contains 5,819 ha of which 4,217 ha are in improved pastures. In the native state the eastern half of the unit, which borders the St. Johns River, was poorly drained and subject to seasonal flooding. Dikes, pumps to remove excessive water, and drainage ditches were installed which allowed improved pastures to be developed. The west half of the unit is generally well

TABLE 1. TOTAL AREA, NUMBER OF COWS, AMOUNT OF IMPROVED PASTURE PER COW, AND AVERAGE WEANING WEIGHT BY MANAGEMENT UNIT

Unit	Total area, ha	Number of cows[a]	Improved pasture/cow, ha	Average weaning weight (1985), kg
2	5,819	2,355	1.79	221
3	6,851	3,171	1.90	197
4	8,345	3,352	1.93	214
5	10,616	2,942	2.70	190
6	10,887	3,286	1.53	194
8	7,955	2,272	2.29	203
9	9,581	2,174	1.19	209
11	10,504	2,226	1.41	190
12	5,549	2,181	1.81	201
16	6,737	2,506	1.12	195

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[a] Number of cows on that unit during 1985 including non lactating cows, 2-yr-olds and those with incomplete data.

enough drained that it is not subject to prolonged seasonal flooding. Most improved pastures are combinations of bahiagrass and Pangola digitgrass. White clover grows in many pastures on the east half of the unit where artesian wells are located. The unimproved portion of the unit is predominantly oak and cabbage palm hammocks or cypress swamps that provide very little cattle forage. The unit's 1985 average weaning weight was 221 kg.

Unit 3. Contains 6,851 ha of which 6,026 ha are in improved pastures. Generally, the improved area is composed of well-drained pastures planted almost exclusively to bahiagrass. The unimproved area is composed mostly of cypress swamps. The unit's 1985 average weaning weight was 197 kg.

Unit 4. Contains 8,345 ha of which 6,474 ha are in improved pastures. The southern half of the unit is poorly drained and contains large areas of cypress swamps. In this portion of the unit, Pangola digitgrass-bahiagrass mixed pastures predominate with a few pastures also containing white clover. The northern portion of the unit is better drained and is planted in bahiagrass. While most of the unimproved area of the unit is cypress or hardwood swamps that provide very little cattle forage, some winter grazing is provided by burning the limited areas of pine and palmetto flatwoods area. The unit's 1985 average weaning weight was 214 kg.

Unit 5. Contains 10,616 ha of which 8,013 ha are in improved or semi-improved pastures. The improved pastures are predominantly planted to bahiagrass. The semi-improved pastures were originally planted to bahiagrass and/or Pangola digitgrass but have experienced major encroachment by wiregrass (*Aristida stricta)*, carpetgrass (*Axonopus affinis*) and broomsedge bluestem (*Andropogon virginicus*). The unimproved portion of the unit consists of some scattered cypress swamps, hardwood swamps along streams, and sizable areas of palmetto and pine flatwoods. While drainage is generally adequate to avoid widespread standing waters during most rainfall events, some areas are subjected to flooding at least annually. The unit's 1985 average weaning weight was 190 kg.

Unit 6. Contains 10,887 ha of which 5,013 ha are in improved pastures. The east portion which borders the St. Johns River has large unimproved areas of sawgrass (*Cladium jamaicense)*, sand cordgrass (*Spartina bakeri)* and maidencane (*Panicum hemitomon)* as well as improved pastures that are drained and planted in Pangola digitgrass and white clover. Most improved pastures in this portion of the unit have artesian wells. The western portion of the unit consists of adequately drained bahiagrass pastures plus large tracts of unimproved palmetto and pine flatwoods that are burned to provide winter forage. The unit's 1985 average weaning weight was 194 kg.

Unit 8. Contains 7,955 ha of which 5,212 ha are in improved or semi-improved pastures. The improved pastures are predominantly planted to bahiagrass but several large pastures of limpograss are used as stockpiled winter grazing. The semi-improved areas were originally planted to bahiagrass but since have experienced major encroachment by wiregrass, carpetgrass and broomsedge bluestem. The unimproved portion of the unit consists of scattered cypress ponds, pine and palmetto flatwoods, and entisols (soil types) with scrub oaks predominating as vegetation. Portions of the unit are excessively drained and have very limited feed during prolonged dry periods. Other portions of the unit are poorly drained and experience seasonal flooding. The unit's 1985 average weaning weight was 203 kg.

Unit 9. Contains 9,581 ha of which 2,593 ha are in improved pastures and 1,198 ha are muck soils. The balance, which is unimproved, consists of cypress swamps, oak and cabbage palm hammocks, and palmetto and pine flatwoods. The improved pastures are predominantly bahiagrass-Pangola digitgrass mixtures with white clover growing in those pastures with artesian wells. The muck soil, which is seasonally subject to severe flooding, produces excellent maidencane pasture during most years. The unit's 1985 average weaning weight was 209 kg.

Unit 11. Contains 10,504 ha of which 3,140 ha are in improved or semi-improved pastures. The improved pastures are planted to bahiagrass. The semi-improved pastures were planted to bahiagrass originally but have experienced major encroachment by wiregrass, carpetgrass, and broomsedge bluestem. The unimproved portion of the unit consists of pine and palmetto flatwoods, well interspersed with cypress ponds, as well as entisols (soil type) with scrub oaks and palmetto predominating as vegetative growth. The unit is generally well drained and tends to be susceptible to drought in the spring and other dry periods. The unit's 1985 average weaning weight was 190 kg.

Unit 12. Contains 5,549 ha of which 3,948 ha are in improved pastures. The improved pastures are predominantly bahiagrass-Pangola digitgrass mixtures with white clover growing in those pastures with artesian wells. The unimproved portion of the unit is composed of scattered cypress ponds, oak and cabbage palm hammocks, diked and drained muck-sand combination wetlands supporting carpetgrass, maidencane and other native forages. The drainage system is adequate to avoid widespread flooding during normal rainfall. The unit's 1985 average weaning weight was 201 kg.

Unit 16. Contains 6,737 ha of which 2,817 ha are in improved pastures. The improved portion of the unit is planted almost exclusively in bahiagrass. The unimproved portion of the unit is composed of scattered cypress pond and hardwood swamps as well as large tracts of pine and palmetto woods. Drainage in the majority of the improved area, is generally adequate to prevent standing water during most rainfalls. The unit's 1985 average weaning weight was 195 kg.

Table 2 shows the distribution of the cows included in this study by management unit and cow age and Table 3 shows the distribution by management unit and breed type.

Cattle and Breeding Program

The cow herd, from which data for this study were collected, was developed from "native cracker" cows purchased in 1950. Brahman bulls were mated to these cows and heifers from this cross were kept for herd replacements. These replacement cows were bred to Hereford and Angus bulls with heifers for herd replacement being retained. Prior to 1981, heifers from this cross and subsequent matings were bred to Brahman, Charolais, Victoria (3/4 Hereford,1/4 Brahman), Brangus and Angus bulls. The use of Charolais bulls was discontinued after 1975. The decision as to which bull breed to use on a particular herd of cows was based partially on phenotype and partially on available bulls and convenience. In 1981 the entire cow herd was classified into either Braford-type, Brangus-type, Charbray-type or Brahman-type herds. Since exact parentage was impossible to determine, this classification process was based on phenotype. The Brangus herds included all solid red and black cows plus the few solid faced brindles (i.e. brindles without a white face). Phenotypically, they appeared to have from 1/8 to 1/2 Brahman

TABLE 2. NUMBER OF COWS BY AGE AND MANAGEMENT UNIT

	Management unit					
Age, yr	2	3	4	5	6	8
3	230 (7.0)[a]	365 (11.0)	491 (14.8)	535 (16.2)	378 (11.4)	400 (12.1)
4	96 (3.9)	271 (10.9)	328 (13.2)	265 (10.7)	257 (10.4)	44 (1.8)
5	169 (5.8)	253 (8.7)	393 (13.5)	278 (9.6)	340 (11.7)	349 (12.0)
6	176 (10.6)	280 (16.8)	206 (12.4)	85 (5.1)	363 (21.8)	123 (7.4)
7	54 (3.1)	195 (11.2)	253 (14.5)	191 (11.0)	250 (14.3)	109 (6.3)
8	89 (3.6)	318 (12.8)	265 (10.6)	221 (8.9)	268 (10.8)	237 (9.5)
9	68 (3.1)	351 (15.9)	319 (14.5)	288 (13.1)	181 (8.2)	150 (6.8)
10	50 (2.8)	318 (17.8)	332 (18.6)	165 (9.3)	148 (8.3)	108 (6.1)
11	67 (5.7)	89 (7.5)	181 (15.3)	121 (10.2)	121 (10.2)	240 (20.3)
12	18 (2.9)	52 (8.4)	118 (19.0)	116 (18.7)	75 (12.1)	106 (17.1)
13	13 (3.5)	21 (5.6)	47 (12.5)	34 (9.1)	32 (8.5)	119 (31.7)
>13	26 (5.0)	41 (7.9)	39 (7.5)	157 (30.1)	100 (19.2)	8 (1.5)
Total number	1,056 (5.0)[c]	2,554 (12.0)	2,972 (14.0)	2,456 (11.6)	2,513 (11.8)	1,993 (9.4)

TABLE 2. (continued)

Age, yr	Management unit 9	11	12	16	Total number
3	238 (7.2)	241 (7.3)	284 (8.6)	149 (4.5)	3,311 (15.6)[b]
4	764 (30.8)	79 (3.2)	222 (9.0)	155 (6.2)	2,481 (11.6)
5	223 (7.7)	272 (9.4)	297 (10.2)	331 (11.4)	2,905 (13.7)
6	48 (2.9)	17 (1.0)	174 (10.4)	195 (11.7)	1,667 (7.8)
7	22 (1.3)	174 (10.0)	166 (9.5)	330 (18.9)	1,744 (8.2)
8	90 (3.6)	556 (22.3)	155 (6.2)	293 (11.8)	2,492 (11.7)
9	139 (6.3)	153 (6.9)	228 (10.3)	328 (14.9)	2,205 (10.4)
10	129 (7.2)	134 (7.5)	143 (8.0)	257 (14.4)	1,784 (8.4)
11	106 (9.0)	51 (4.3)	81 (6.9)	126 (10.7)	1,183 (5.6)
12	7 (1.1)	23 (3.7)	28 (4.5)	77 (12.4)	620 (2.9)
13	1 (0.3)	18 (4.8)	24 (6.4)	66 (17.6)	375 (1.8)
>13	11 (2.1)	15 (2.9)	36 (6.9)	89 (17.1)	522 (2.5)
Total number	1,778 (8.4)	1,733 (8.1)	1,838 (8.6)	2,396 (11.3)	21,289

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a Numbers in parenthesis indicate frequency percentage by management unit of that age animal.
b Numbers in parenthesis indicate percentage of total cows which were that age.
c Numbers in parenthesis indicate percentage of total cows on that unit.

TABLE 3. NUMBER OF COWS BY MANAGEMENT UNIT AND BREED TYPE

	Breed type				
Unit	Brangus	Braford	Charbray	Brahman	Total number
2	418 (38.7)[a]	326 (30.2)	0 (0)	336 (31.1)	1,080 (5.0)[b]
3	0 (0)	502 (19.0)	2,140 (81.0)	0 (0)	2,642 (12.3)
4	0 (0)	2,992 (100.0)	0 (0)	0 (0)	2,992 (13.9)
5	2,141 (85.9)	231 (9.2)	20 (0.8)	102 (4.1)	2,494 (11.6)
6	1,768 (68.7)	805 (31.3)	2 (0.1)	1 (0)	2,576 (11.9)
8	656 (32.9)	683 (34.3)	243 (12.2)	411 (20.7)	1,993 (9.2)
9	0 (0)	892 (50.2)	886 (49.8)	0 (0)	1,778 (8.2)
11	20 (1.1)	1,687 (95.6)	52 (2.9)	7 (0)	1,766 (8.2)
12	0 (0)	1,841 (100.0)	0 (0)	0 (0)	1,841 (8.5)
16	383 (15.9)	0 (0)	0 (0)	2,024 (84.1)	2,407 (11.2)
Total number	5,386 (25.0)[c]	9,959 (46.2)	3,343 (15.5)	2,881 (13.4)	21,569

[a] Numbers in parenthesis indicate frequency percentage by breed type within that unit.
[b] Numbers in parenthesis indicate percentage of total cows on that unit.
[c] Numbers in parenthesis indicate percentage of total cows of that breed type.

(*Bos indicus*) breeding and considerable Angus influence in their genetic makeup. The typical cow in these herds appeared to be similar to what would be expected in a 5/8 Angus:3/8 Brahman cow. The Braford herds included the red, black and brindle cows with the typical Hereford white face. While the range of *Bos indicus* breeding appeared to be similar to that of the Brangus herds (i.e. 1/8 to 1/2), the typical cow phenotypically displayed less Brahman influence and appeared to be similar to what would be expected in a 1/4 *Bos indicus* cross cow with considerable Hereford breeding. The Charbray herds included cows displaying either the homozygous or heterozygous effects of the Charolais dilution factor, as evidenced by a white, yellow or light grey coat color, and those cows sired by Simbrah bulls. Therefore, these herds included cows that phenotypically appeared to be 1/2 or less *Bos indicus* and were either solid white or showed the typical Angus or Hereford-Charolais crossbred color patterns. The typical cow 4 through 8 yr of age in these herds appeared phenotypically to be similar to what would be expected in a 3/8 *Bos indicus* x Charolais crossbred. The typical cow 9 yr of age and older appeared to be 1/2 or more Charolais and less than 1/4 Brahman. The Brahman herds included all cows that appeared to be more than 1/2 *Bos indicus* breeding despite color. The typical animal appeared to be similar phenotypically to what would be expected in a 7/8 *Bos indicus* cow.

A three way rotational crossbreeding system was initiated in 1981, in which the Brangus type cows and all subsequent Brangus-sired females were mated to Braford bulls, the Braford-type cows and subsequent Braford-sired females were mated to Simbrah bulls, and the Charbray-type cows and subsequent Simbrah-sired females were mated to Brangus bulls. The Brahman-type cows were mated to either Angus or Simmental bulls.

General Cattle Management

The cows were maintained in herds of approximately 250 head and were exposed to bulls at a ratio of 30 cows:1 bull during a 4 mo breeding season extending from March 1 to July 1. Data for this study were collected only from those cows confirmed pregnant by rectal palpatation in 1984, so most of these cows had been lactating during the 1985 breeding season. A limited number of cows (approximately 4%) were not lactating at the time of breeding. The non-lactating animals included cows that aborted after being diagnosed pregnant, those that were incorrectly diagnosed as pregnant, and those whose calves had died during or after birth. Since 1981, the cows were culled based on pregnancy status and age. All non-pregnant cows over 8 yr of age were culled and all other non-pregnant cows were fire branded with a bar(-) on the hip. Any such bar-branded cow not pregnant at any subsequent annual pregnancy testing in the fall or not lactating during any subsequent spring was culled.

Starting in 1981, replacement heifers were exposed when approximately 12 to 14 mo old to Angus bulls for 60 d commencing March 1. Each year approximately 50% of the heifers conceived to calve at 2 yr of age. Those not conceiving as yearlings were exposed at approximately 24 to 26 mo of age for 75 d to bulls of the breed prescribed in the rotational crossbreeding program. Those heifers not conceiving during this period were culled. The lactating 2- and 3-yr-old cows were managed as separate herds. In general, they were provided the best pastures (clover-grass combinations or ryegrass) during the calving and breeding periods. They frequently received extra supplementation during these periods, especially if it appeared body condition was beginning to decline. Subsequent to the breeding period they had access to pastures of similar forage quality as that available to the older cows.

Cows in this study ranged in age from 3 to 24 yr, with an average age of 6.9 yr. Table 4 shows the age distribution by breed type for the cows included in this study.

All cows were supplemented for 75 d during the previous winter (Dec. 15, 1984 through March 1, 1985) with heavy mill-run molasses fed ad libitum. Average daily molasses consumption was approximately 1.8 kg per head. Additionally, 1.6 kg of a 35% all natural protein cube were fed twice weekly for the same 75 d. A mineral mixture containing 12% calcium and 12% phosphorus plus trace minerals was available free choice year round, and daily consumption was approximately 57

TABLE 4. NUMBER OF COWS BY AGE AND BREED TYPE

	Breed type				
Age, yr	Brangus	Braford	Charbray	Brahman	Total number
3	1,244 (37.6)[a]	1,752 (52.9)	64 (1.9)	251 (7.6)	3,311 (15.6)[b]
4	599 (24.1)	1,414 (57.0)	280 (11.3)	188 (7.6)	2,481 (11.7)
5	761 (26.2)	1,233 (42.4)	468 (16.1)	443 (15.3)	2,905 (13.7)
6	396 (23.8)	653 (39.2)	328 (19.7)	290 (17.4)	1,667 (7.8)
7	367 (21.0)	803 (46.0)	282 (16.2)	292 (16.7)	1,744 (8.2)
8	410 (16.5)	1,260 (50.6)	492 (19.7)	330 (13.2)	2,492 (11.7)
9	435 (19.7)	919 (41.7)	505 (22.9)	346 (15.7)	2,205 (10.4)
10	301 (16.9)	763 (42.8)	467 (26.2)	253 (14.2)	1,784 (8.4)
11	240 (20.3)	543 (45.9)	216 (18.3)	184 (15.6)	1,183 (5.6)
12	183 (29.5)	257 (41.5)	65 (10.5)	115 (18.6)	620 (2.9)
13	94 (25.1)	153 (40.8)	30 (8.0)	98 (26.1)	3,752 (1.8)
>13	249 (47.7)	132 (25.3)	57 (10.9)	84 (16.1)	522 (2.5)
Total number	5,279 (24.8)[c]	9,882 (46.4)	3,254 (15.3)	2,874 (13.5)	21,289

a Numbers in parenthesis indicate frequency percentage by breed type of that age.
b Numbers in parenthesis indicate percentage of total cows which were that age.
c Numbers in parenthesis indicate percentage of total cows of that breed type.

g per head. The cows had been confirmed to be brucellosis free by serological test and were vaccinated twice yearly (spring and fall) for leptospirosis and vibriosis. Theanimals were treated the previous fall with the broad spectrum anthelminthic, levamisole phosphate, by injection. Hornflies were controlled by an impregnated ear tag, containing a synthetic pyrethroid, applied in April. Most of the cows weighed between 380 and 410 kg and had weaned calves averaging 205 kg in September immediately before these data were gathered.

Cows were stocked at a rate of about one cow per 1.8 ha of improved pasture. Approximately .4 ha was fertilized annually per cow with a single application in March or September of 50 kg of nitrogen, 20 kg of phosphorous and 20 kg of potassium per hectare. The soil pH on improved pastures was maintained between 5.5 to 6.5 by application of lime. When broadleaf weeds were ascertained by the ranch management to be a problem, they were controlled by an aerial application of a herbicide containing 2,4-D (2,4-dichlorophenoxyacetic acid) and dicamba (3,6-dichloro-o-anisic acid).

Stocking rates in the unimproved areas varied widely but averaged 1 cow per 8 ha. Many flatwoods areas were burned during the previous fall and winter months to provide better winter and spring forage by stimulating wiregrass regrowth. In both the improved and unimproved pastures, two to three pastures were assigned to each herd to allow for rotational grazing. The cattle were moved within a rotation based on management's evaluation of the animals' needs, forage availability and anticipated regrowth.

These data were collected during the ranch's fall cow processing during October and November. All bulls had been removed from the cow herds for at least 90 d. Experienced ranch personnel diagnosed pregnancy status by rectal palpation. Each cow was assigned a pregnancy code of 1 (pregnant) or 0 (not pregnant). Cow age was derived from the year of birth fire brand found on each animal. Each cow was also assigned a body condition score (BCS), arrived at by the consensus of at least two ranch personnel experienced in the BCS system described by Herd and Sprott (1986). A description of the BCS system is given in Table 5, and Tables 6, 7 and 8 show the distribution of the cows included in this study by BCS and management unit, cow age and breed type respectively.

Statistical Analyses

The data were analyzed using the general linear model procedures (Proc GLM) of the Statistical Analysis System (SAS, 1982). Sources of variation included in the analysis of variance (ANOVA) for pregnancy rate were the main effects of body condition score (BCS), breed type, management unit, and age of cow. Additionally, all two-way interactions were included except breed type x management unit which was deleted because of partial confounding of breed type with management unit. For purposes of analysis, the cows were grouped into seven age groups; 3 yr, 4 yr, 5 and 6 yr, 7 and 8 yr, 9 and 10 yr, 11 and 12 yr, and 13 yr and older. Combining of the 13 yr

TABLE 5. DESCRIPTION OF BODY CONDITION SCORES (BCS)

BCS	Description
1	Emaciated--Bone structure of shoulder, ribs, back, hooks and pins sharp to touch and easily visible. Little evidence of fat deposits or muscling.
2	Very Thin--Little evidence of fat deposits but some muscling in hindquarters. The spinous processes feel sharp to touch and are easily seen with space between them.
3	Thin--Beginning of fat cover over the loin, back and foreribs. Backbone still highly visible. Processes of the spine can be identified individually by touch and may still be visible. Spaces between the processes are less pronounced.
4	Borderline--Foreribs not noticeable; 12th and 13th ribs still noticeable to the eye, particularly in cattle with a big spring of rib and ribs wide apart. The transverse spinous processes can be identified only by palpation (with a slight pressure) to feel rounded rather than sharp. Full but straightness of muscling in the hindquarters.
5	Moderate--12th and 13th ribs not visible to the eye unless animal has been shrunk. The transverse spinous processes can only be felt with firm pressure to feel rounded-not noticeable to the eye. Spaces between the processes not visible and only distinguishable with firm pressure. Areas on each side of the tail head are fairly well filled but not mounded.
6	Good--Ribs fully covered, not noticeable to the eye. Hindquarters plump and full. Noticeable sponginess to covering of foreribs and on each side of the tail head. Firm pressure now required to feel transverse processes.
7	Very Good--Ends of the spinous processes can only be felt with very firm pressure. Spaces between processes can barely be distinguished at all. Abundant fat cover on either side of tail head with some patchiness evident.
8	Fat--Animal taking on a smooth, blocky appearance; bone structure disappearing from sight. Fat cover thick and spongy with patchiness likely.
9	Very Fat--Bone structure not seen or easily felt. Tail head buried in fat. Animal's mobility may actually be impaired by excess amount of fat.

TABLE 6. NUMBER OF COWS BY MANAGEMENT UNIT AND BODY CONDITION SCORE

Unit	Body condition score 3	4	5	6	Total number
2	45 (4.2)[a]	636 (58.1)	373 (32.9)	55 (4.8)	1,107 (5.1)[b]
3	495 (18.7)	1,643 (62.2)	466 (17.6)	38 (1.5)	2,642 (12.2)
4	287 (9.6)	1,767 (59.1)	827 (27.6)	111 (3.7)	2,992 (13.9)
5	309 (12.4)	1,515 (60.8)	596 (23.9)	74 (2.9)	2,494 (11.6)
6	180 (7.0)	1,548 (60.1)	676 (26.2)	172 (6.7)	2,576 (11.9)
8	372 (18.7)	1,221 (61.3)	373 (18.7)	27 (1.3)	1,993 (9.2)
9	80 (4.5)	951 (53.5)	714 (40.2)	33 (1.8)	1,778 (8.2)
11	320 (18.1)	1,171 (66.3)	244 (13.8)	31 (1.8)	1,766 (8.2)
12	178 (9.7)	1,158 (62.9)	470 (25.5)	35 (1.9)	1,841 (8.5)
16	304 (12.6)	1,422 (59.1)	633 (26.3)	48 (2.0)	2,407 (11.2)
Total number	2,570 (11.9)[c]	13,023 (60.4)	5,355 (24.8)	621 (2.9)	21,569

[a] Numbers in parenthesis indicate frequency percentage by body condition score within that unit.

[b] Numbers in parenthesis indicate percentage of total cows on that unit.

[c] Numbers in parenthesis indicate percentage of total cows with that body condition score.

TABLE 7. NUMBER OF COWS BY AGE AND BODY CONDITION SCORE

	Body condition score				
Age, yr	3	4	5	6	Total number
3	444 (13.4)[a]	1,887 (57.0)	873 (26.4)	107 (3.2)	3,311 (15.6)[b]
4	159 (6.4)	1,493 (60.2)	788 (31.8)	41 (1.6)	2,481 (11.7)
5	264 (9.1)	1,745 (60.0)	773 (26.6)	123 (4.2)	2,905 (13.6)
6	101 (6.1)	966 (57.9)	534 (32.0)	66 (4.0)	1,667 (7.8)
7	146 (8.4)	1,024 (58.8)	502 (28.8)	72 (4.1)	1,744 (8.2)
8	284 (11.4)	1,600 (64.2)	552 (22.2)	56 (2.2)	2,492 (11.7)
9	277 (12.6)	1,366 (62.0)	479 (21.7)	83 (3.8)	2,205 (10.4)
10	270 (15.1)	1,086 (60.9)	396 (22.2)	32 (1.8)	1,784 (8.4)
11	199 (16.8)	747 (63.1)	219 (18.5)	18 (1.5)	1,183 (5.6)
12	111 (17.9)	391 (63.1)	110 (17.7)	8 (1.3)	620 (2.9)
13	91 (24.2)	231 (61.6)	49 (13.1)	4 (1.1)	375 (1.8)
>13	172 (33.0)	290 (55.6)	53 (10.2)	7 (1.3)	522 (2.5)
Total number	2,518 (11.8)[c]	12,826 (60.2)	5,328 (25.0)	617 (2.9)	21,289

a Numbers in parenthesis indicate frequency percentage by body condition score of that age animal.
b Numbers in parenthesis indicate percentage of total cows which were that age.
c Numbers in parenthesis indicate percentage of total cows with that body condition score.

TABLE 8. NUMBER OF COWS BY BREED TYPE AND BODY CONDITION SCORE

Breed type	Body condition score				Total number
	3	4	5	6	
Brangus	644 (12.0)[a]	3,331 (61.8)	1,217 (22.6)	194 (3.6)	5,386 (25.0)[b]
Braford	1,138 (11.4)	6,055 (60.8)	2,498 (25.1)	268 (2.7)	9,959 (46.2)
Charbray	453 (13.5)	1,138 (58.8)	838 (25.0)	86 (2.6)	3,346 (15.5)
Brahman	335 (11.6)	1,671 (58.0)	802 (27.8)	73 (2.5)	2,881 (13.4)
Total number	2,570 (11.9)[c]	13,023 (60.4)	5,355 (24.8)	621 (2.9)	21,569

a Numbers in parenthesis indicate frequency percentage by body condition score within that breed type.

b Numbers in parenthesis indicate percentage of total cows within that breed type.

c Numbers in parenthesis indicate percentage of total cows with that body condition score.

and older cows into one age group for analysis purposes was made to avoid non-estimable least-squares means for some interactions due to limited numbers. The 5- to 12-yr-old cows were combined into four age groups for analysis purposes because of physiological and reproductive similarities and for ease of analysis. Data were collected for 21,665 cows. Because of limited numbers (96), BCS 2 animals were not included in the analyses. Additionally, cows with incomplete data sets were deleted. Data from 21,141 cows were included in the analyses. Least-squares means were compared using the T-test provided by the PDIFF option of Proc GLM.

Because preliminary analyses showed that BCS accounted for a large portion of the variation in pregnancy rates, the data were analyzed to determine the effects, within each BCS, of the other factors on pregnancy rate. Thus, within each BCS, a separate ANOVA was calculated with pregnancy rate as the dependent variable and breed type, management unit, age of cow and the interactions of management unit x age of cow and breed type x age of cow included as sources of variation.

An additional analysis was made to determine the factors influencing BCS. In this ANOVA with BCS as the dependent variable, the independent variables were breed type, management unit, age of cow and the interactions of management unit x age of cow and breed type x age of cow. Data from 21,198 cows were included in this analysis.

Results and Discussion

Pregnancy Rate Across Body Condition Score

The mean pregnancy rate for all cows (n=21,289) was 78%. Pregnancy rate was affected (P < .02) by body condition score (BCS), management unit, age, and the interactions between BCS x age, BCS x management unit, management unit x age, and breed type x age (Table 9). The BCS x breed type interaction tended to affect (P < .056) pregnancy rate, whereas breed type had no impact (P > .3045).

TABLE 9. ANALYSIS OF VARIANCE FOR FACTORS AFFECTING PREGNANCY RATE

Source	df	Mean squares	F	P
Body condition score (BCS)	3	57.58	401.74	.0001
Breed type	3	.17	1.21	.3045
Management unit	9	.99	6.88	.0001
Age of cow	6	.36	2.53	.0190
BCS x age	18	.28	1.94	.0097
BCS x breed type	9	.26	1.84	.0559
BCS x management unit	27	.56	3.89	.0001
Management unit x age	54	.51	3.55	.0001
Breed type x age	18	.26	1.85	.0154
Error	21,141	.14		

Body Condition Score

Large differences (P < .0001) in pregnancy rate were observed due to variations in BCS. Pregnancy rates ranged from 43.2% in BCS 3 cows, to 76.4% in BCS 4 cows and to 92.7% and 96.9% in BCS 5 and 6 cows respectively (Table 10). Differences in pregnancy rates between BCS 3 and 4 cows and between BCS 4 and 5 cows were significant. No significant differences in pregnancy rate existed between BCS 5 and 6 cows. The BCS had the largest effect on pregnancy rate of any variable analyzed and resulted in a 54 percentage point range in pregnancy rates among the different BCS groups. In particular, the greatest difference observed in pregnancy rates (33 percentage points) was between BCS 3 and 4 cows.

TABLE 10. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE BY BODY CONDITION SCORE

	Pregnancy rate (%)	
Body condition score	LSM	SE
3	43.2^a	1.2
4	76.4^b	0.6
5	92.7^c	0.9
6	96.9^c	2.8

a,b,c Means that do not have a common superscript differ (P < .0001).

Most workers have tested variations in pregnancy rates due to variations in BCS at calving or the beginning of the breeding period. The BCS in these data were taken at the time of pregnancy testing, which was 30 to 60 d after weaning. This would have been approximately 6 to 10 mo postpartum. It is probable that BCS changed from calving to the time these data were collected, due to the high energy demands of lactation and the summer decline in forage quality typically observed under Florida conditions. Variations in pregnancy rate associated with changes in BCS found in the present study, however, were similar to those found in other studies where body condition was scored at breeding or calving (Richards et al.,1986; Selk et al., 1988).

Management Unit

Differences (P < .0001) in pregnancy rates were found among management units (Table 9); however, an interpretation of these differences is difficult because they can be attributed to many factors such as management skills of foremen, feed quality and quantity, and differences in precipitation. Nevertheless, units 16, 6, 9 and 11 which had the lowest pregnancy rates (Table 11) also had the least improved pasture per cow (Table 1). This finding is in agreement with Reynolds (1960) and Peacock et al. (1971), who reported lower pregnancy rates for cows grazing native pastures. Because of the inability to further discern the causes of these differences, additional discussion of the effects of management unit and interactions involving management unit will not be attempted.

Cow Age

Age of cow affected (P < .019) reproductive performance (Table 9). Pregnancy rates ranged from 81% in the 3-yr-old cows to 72.3% in the 11 and 12 yr age group (Table 12). Reproductive performance began to decline at 9 yr of age, reached the lowest level in the 11 and 12 yr age group, and tended to increase in the 13 yr and older age group. The tendency toward an increase in pregnancy rate in the 13 yr and older age group was inconsistent with the results reported by

TABLE 11. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE BY MANAGEMENT UNIT RANKED BY PREGNANCY RATE

	Pregnancy rate (%)	
Management unit	LSM	SE
8	85.4^{a}	3.0
3	82.6^{ab}	3.1
4	82.0^{ab}	2.0
12	79.4^{abc}	2.5
2	79.1^{abc}	2.6
5	78.0^{bc}	1.9
11	74.9^{bcd}	2.7
9	73.4^{cd}	3.5
6	72.3^{d}	1.8
16	65.8^{e}	2.6

a,b,c,d,e Means that do not have a common subscript differ (P < .05).

TABLE 12. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE BY AGE

	Pregnancy rate (%)	
Age, yr	LSM	SE
3	81.0^{a}	1.9
4	76.9^{ab}	2.0
5 & 6	79.5^{a}	1.1
7 & 8	78.7^{ab}	1.3
9 & 10	75.9^{b}	1.3
11 & 12	72.3^{c}	2.2
13 & older	76.7^{ab}	3.6

a,b,c, Means that do not have a common superscript differ ($P < .05$).

Peacock et al. (1976) and Reynolds (1960). A possible explanation is that the practice of culling nonpregnant cows 8 yr of age and older might have eliminated many of the least fertile cows, thus modifying any negative effect of age on reproductive performance. While the practice of culling nonpregnant cows might tend to result in older cattle with high fertility, distortions of least-squares means probably also are partially responsible for the seeming increase in pregnancy rate in the 13 yr of age and older cows. This will be further discussed with the BCS x cow age interaction.

The observation of similar pregnancy rates in the 3-yr-old cows and the 5- to 8-yr-old cows was also inconsistent with the results reported by Peacock et al. (1976) and Reynolds (1960), who reported lower pregnancy rates for lactating 3-yr-old cows. The lack of differences in pregnancy rates in the above mentioned age groups may have been due to the fact that lactating 3-yr-old cows were managed as separate herds. They had access to the best pastures (clover-grass combinations or ryegrass) and frequently received extra supplementation.

Body Condition Score and Age of Cow Interaction

Pregnancy rates in cows with BCS of 3 and 4 declined after the animals were 8 yr of age but remained essentially the same at all ages for BCS 5 and 6 cows (Table 13). Pregnancy rates for the cows 13 yr of age and older with BCS 3 and 4 were the lowest of any age group. Older cows with BCS 5 and 6 tended to have high pregnancy rates, but the

TABLE 13. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE (%) BY BODY CONDITION SCORE AND AGE

	Body condition score							
	3		4		5		6	
Age, yr	LSM	SE	LSM	SE	LSM	SE	LSM	SE
3	52.7	2.6	76.0	1.6	94.2	2.0	101.0	4.7
4	42.4	3.3	77.1	1.4	92.3	2.0	95.9	6.2
5 & 6	44.8	2.2	80.7	0.9	94.1	1.2	98.5	3.2
7 & 8	45.6	2.2	79.2	1.0	92.4	1.4	97.7	3.8
9 & 10	39.5	2.0	74.6	1.0	91.1	1.5	98.6	3.9
11 & 12	39.0	2.5	74.4	1.4	91.8	2.3	83.9	7.7
13 & older	38.3	3.0	72.7	2.3	93.1	4.1	102.8	11.9

percentage of older cows with BCS 5 and 6 was lower than the percentage of younger cows with BCS of 5 and 6 (Table 7). These differential responses resulted in a significant interaction between BCS and cow age (Table 9). Only 26 of the 11- and 12-yr-old cows had a BCS of 6, so little confidence can be given to the decline noted in pregnancy rate (Table 7). Similarly, the 13 and older BCS 6 group included only 11 cows so little credibility can be given to the high pregnancy rate obtained, as is evidenced by the large standard error. In the computation of least-squares means for pregnancy rate by cow age across all BCS, equal weight would be given to each BCS regardless of the numbers of cows involved. Thus, the mean for the 13 yr and older age group is probably distorted due to the disproportionate weight given to pregnancy rates for the limited number of BCS 5 and 6 cows of that age. The pregnancy rate observed in the 3-yr-old BCS 3 cows was higher than that obtained in the older BCS 3 cows and might suggest that the 3-yr-olds may have been in better condition at calving but had subsequently lost condition.

Breed Type

Breed type did not have a significant impact on pregnancy rate (Table 9). Pregnancy rates for the Brangus, Braford, Charbray and Brahman breed types were 79.3, 77.6, 77.6, 74.7% respectively (Table 14), with the difference between the Brangus and Brahman breed types approaching significance ($P < .067$). Reynolds (1960) and Peacock et al. (1971) reported higher reproductive performance in crossbred cattle than in the straightbred parent breeds. Peacock et al. (1971) attributed the increased pregnancy rates in the crossbred cattle to heterosis. The Brahman breed type in this study was composed of cows phenotypically displaying high percentages of *Bos indicus* breeding but also having some *Bos taurus* breeding. The lack of difference in reproductive performance among the four breed types could possibly have been because the cows classified as the Brahman breed type would have been expected to have some heterozygosity, and therefore they would have exhibited some heterosis. While the Brahman breed type would be expected to exhibit some heterosis, the level of heterozygosity should have been somewhat less than in the other three breeds types, therefore, the expected heterosis would also have been somewhat less.

There was a significant breed type x cow age interaction (Table 9). Although there was some variation in pregnancy rates among the different age groups; in general, pregnancy rates were relatively constant across ages groups in the Brangus and Braford breed types (Table 15). In contrast, the Brahman breed type tended to have lower pregnancy rates at younger and older ages than in the 5- through 8-yr-old cows.

TABLE 14. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE BY BREED TYPE

	Pregnancy rate (%)	
Breed type	LSM	SE
Brangus	79.3[a]	1.8
Braford	77.6	1.5
Charbray	77.6	3.0
Brahman	74.7	2.4

[a] The Brangus breed type tended ($P < .067$) to have a higher pregnancy rate than did the Brahman breed type.

Williams et al. (1991) reported that direct additive gene effects in Brahman cattle resulted in lower calving rates than in Angus, Charolais and Hereford cows; however, the heterotic effects on calving rates in Brahman x *Bos taurus* crossbreeds were positive. Similarly, Olson (personal communication) found that additive direct gene effects for Angus cattle on pregnancy rate were superior to those of the Brahman and Charolais breeds, and that the effects of heterozygosity on pregnancy rates for both Brahman x Angus and Brahman x Charolais crossbred cows were substantial. In the present study, pregnancy rates did not differ among the four breed types; however, the lower reproductive performance in the younger and older Brahman breed type cows might have been because lower additive direct gene effects of the Brahman breed for calving rate were expressed at younger and older ages when stress was greater. Another possible explanation is that heterotic effects in the other three breed types might

TABLE 15. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE (%) BY BREED TYPE AND AGE

	Breed type							
	Brangus		Braford		Charbray		Brahman	
Age, yr	LSM	SE	LSM	SE	LSM	SE	LSM	SE
3	83.8	2.9	77.2	2.4	85.5	6.1	77.5	5.4
4	77.5	5.0	80.4	4.2	81.6	5.3	68.3	6.0
5 & 6	78.5	2.3	77.4	1.8	82.6	3.8	79.6	3.0
7 & 8	75.5	2.4	77.3	1.9	81.1	3.5	80.9	3.5
9 & 10	79.4	2.6	80.8	2.1	67.9	4.6	75.6	3.6
11 & 12	75.1	3.6	73.1	3.0	68.6	6.1	72.4	4.4
13 & older	85.1	5.3	77.1	4.7	76.0	9.1	68.6	6.1

have resulted in higher pregnancy rates at older ages. This explanation is supported by the work of Rohrer et al. (1988) who reported that Brahman-cross cows exceeded the parent breeds in longevity as determined by continued reproduction, survival, lack of structural problems and removal for disease. Similarly, Núñez-Dominguez et al. (1991) found that longevity in crossbred cattle exceeded that of the parent breeds and that cow culling due to poor body condition (emaciation) increased with age but was lower for crosses than for staightbred cattle.

The effect of age on pregnancy rate within the Charbray type cows appeared to reflect changes in percentage Charolais and Brahman breeding. The use of Charolais bulls was discontinued after 1975; therefore, all cows 9 yr and older within this breed type would have probably been 1/2 or more Charolais and less than 1/4 Brahman, whereas the 5- through 8-yr-old cows would have probably been 1/4 or less Charolais and 1/4 to 1/2 Brahman. The 3- and 4-yr-old cows were Simbrah-sired and probably had 1/8 or less Charolais.

Pregnancy Rate Within Body Condition Score

Since BCS accounted for a significant portion of the variation in pregnancy rate, the data were analyzed to determine the effect within each BCS of the other factors on pregnancy (Table 16). The pregnancy rate of BCS 3 cows was significantly affected by management unit and management unit x age interaction but not by breed type, age or breed type x age interaction. Similarly, in BCS 5 cows only management unit x age had a significant impact on pregnancy rate. In contrast, pregnancy in BCS 4 cows was affected by breed type, management unit, age, and management unit x age interaction. These data would suggest that reproductive performance of BCS 4 cows can be influenced by such factors as breed and age of cow.

The typical approach to managing for higher pregnancy rates through BCS is to recommend increasing nutrition for thinner cows, thus resulting in higher BCS and consequently higher pregnancy rates. Situations frequently occur in the cattle industry, however, where inadequate nutrition during either lactation or the forage deficient winter months leads to lowered BCS at the time of breeding. In many of these situations, it may be uneconomical to supplement at a level that will maintain the BCS necessary to obtain high pregnancy rates. Thus, the ability to increase calving rates in BCS 4 cows by controlling other sources of variation for pregnancy rate could have positive effects on the profitability of cattle production in these situations.

The BCS 4 Brangus and Braford type cows had pregnancy rates of 81.7% and 79.5% respectively, which were higher ($P < .05$) than the pregnancy rate of 68.7% in the Brahman type cows with the same BCS (Table 17). The Charbray type cows had a pregnancy rate of 75.9% and did not differ statistically from any of the other breed types. Reynolds (1960) reported higher pregnancy rates in crossbred cattle than in Shorthorn and Brahman straightbreds. He attributed this difference to hybrid vigor. In this study, higher heterosis levels in the

Brangus and Braford type cows may have been responsible for the increased reproductive performance of cows with a BCS of 4 when compared to the relatively straightbred Brahman type cows. Another possible explanation is that the inherent lower fertility levels of the Brahman breed attributed by Olson (personal communication) and Williams et al. (1991) to negative direct additive gene effects were expressed in this study in stressed situations such as those indicated by the marginal BCS of 4.

TABLE 16. ANALYSIS OF VARIANCE PROBABILITY VALUES FOR FACTORS AFFECTING PREGNANCY RATE WITHIN BODY CONDITION SCORE

	Body condition score			
Source	3	4	5	6
Breed type	.58	.0001	.12	.41
Management unit	.0001	.0001	.45	.03
Age of cow	.73	.0003	.72	.96
Management unit x age	.05	.0001	.03	.002
Breed type x age	.91	.095	.26	.004

Management unit and the management unit x age interaction had a significant effect on pregnancy rate for BCS 4 cows (Table 16); although, an interpretation of these differences is difficult because they can be attributed to many factors. As in the general analysis across all BCS, however, units 16, 9, 11 and 6, which had the lowest pregnancy rates (Table 18) also had the least improved pasture per cow (Table 1).

Pregnancy rates of 80.5% in the 5- and 6-yr-old and 79.5% in the 7- and 8-yr-old BCS 4 cows were higher than the 75.1% observed in the 4-yr-old cows as well as the rates of about

TABLE 17. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 4 COWS BY BREED TYPE

	Pregnancy rate (%)	
Breed type	LSM	SE
Brangus	81.7^{a}	1.6
Braford	79.5^{a}	1.3
Charbray	75.9^{ab}	2.8
Brahman	68.7^{b}	2.2

a,b Means that do not have a common superscript differ ($P < .05$).

TABLE 18. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 4 COWS BY MANAGEMENT UNIT

	Pregnancy rate (%)	
Management unit	LSM	SE
3	85.4^{a}	2.9
2	83.4^{a}	2.4
8	82.5^{a}	1.8
4	79.0^{ab}	1.9
5	78.5^{ab}	1.8
12	76.3^{bc}	2.1
6	74.0^{c}	1.8
11	71.7^{c}	2.6
9	71.5^{c}	3.2
16	62.3^{d}	2.2

a,b,c,d Means that do not have a common superscript differ ($P < .05$).

TABLE 19. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 4 COWS BY AGE

	Pregnancy rate (%)	
Age, yr	LSM	SE
3	77.1^{ab}	1.9
4	75.1^{b}	1.7
5 & 6	80.5^{a}	1.0
7 & 8	79.5^{a}	1.2
9 & 10	74.4^{b}	1.2
11 & 12	74.2^{b}	1.7
13 & older	74.1^{b}	2.8

a,b Means that do not have a common superscript differ ($P < .05$).

74% observed in all the older age groups (Table 19). The 3-yr-old BCS 4 cows had a pregnancy rate of 77.1%, which did not differ statistically from the pregnancy rates of the other age groups. The significant age-related decline in pregnancy rates in the BCS 4 cows beginning at 9 yr of age was similar to the tendency observed in the general analysis across all BCS groups (Table 12); however, in the BCS 4 cows no increase in pregnancy rate was observed in the cows 13 yr of age and older.

Body Condition Score

Body condition score is a subjective scoring system developed to rate cows according to fatness or condition (Herd and Sprott, 1986). Even though BCS is a subjective scoring system, it has been demonstrated to predict accurately body energy reserves, since BCS has been reported to be highly correlated (.77) with percent carcass fat (Dunn et al., 1983). Similarly, Wagner et al. (1988) reported that 82% of the variation in total carcass energy could be accounted for by variations in BCS. Cows with low BCS have lower pregnancy rates than cows with higher BCS (Richards et al., 1986; Selk et al., 1988; Kunkle and Sand, 1990; Wiltbank, 1991).

Since pregnancy rate was affected more by BCS than by any other variable included in the analysis, the data were analyzed to determine what effects the other variables had on BCS. Mean BCS was 4.2 and BCS was significantly affected by breed type, management unit, age, and the management unit x age and breed type x age interactions (Table 20).

TABLE 20. ANALYSIS OF VARIANCE FOR FACTORS AFFECTING BODY CONDITION SCORE

Source	df	Mean squares	F	P
Breed type	3	18.93	46.33	.0001
Management unit	9	25.25	61.81	.0001
Age of cow	6	15.52	37.98	.0001
Management unit x age	54	3.42	8.36	.0001
Breed type x age	18	6.42	15.72	.0001
Error	21,198	.41		

The mean BCS for the Charbray, Braford, Brahman and Brangus breed types were 4.4, 4.1, 4.1, and 4.0 respectively (Table 21). The Charbray breed type had the highest (P <. 0001) average BCS, and the Braford and Brahman breed types had higher (P < .0001) average BCS than the Brangus breed type. No biological reason for these differences is apparent. These differences in BCS due to breed type did not result in differences in reproduction performance, since breed type did not significantly affect pregnancy rates (Table 9).

Mean BCS peaked in the 5- through 8-yr-old age groups at 4.3 and declined consistently with increased and decreased age (Table 22). The lowest score observed in any age group was a BCS of 3.9 in the cows 13 yr of age and older. Pregnancy rates in the various age groups generally followed the same trend as BCS except in the 3-yr-old cows and in the 13 yr of age and older group (Table 12). In the 13 yr and older cows, declines in pregnancy rates would have been expected as a result of the significant decline in BCS. However, the overall pregnancy rate tended to increase in this age group. While 13 yr of age and older cows with BCS of 5 or 6 tended to have high

TABLE 21. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY BREED TYPE

	Body condition score	
Breed type	LSM	SE
Brangus	4.0^{a}	.02
Braford	4.1^{b}	.02
Charbray	4.4^{c}	.03
Brahman	4.1^{b}	.03

a,b,c Means that do not have a common subscript differ ($P < .0001$).

pregnancy rates, pregnancy rates for cows 13 yr of age and older with a BCS of 3 or 4 were the lowest of any age group (Table 13). Also, a higher percentage of older than of younger cows had a BCS of 3 and fewer of the older cows had BCS of 5 and 6 than the younger cows (Table 7). Thus the apparent increase in pregnancy rate in the 13 yr of age and older group might have been the result of distortions of the least-squares means caused by giving equal weight in computing the least squares means to the lower number of BCS 5 and 6 cows of that age group. Another possible explanation for the apparent discrepancy of an increasing pregnancy rate with a declining BCS is that the 13 yr and older age group normally would be expected to have more missing and heavily worn teeth and thus have reduced grazing capacity. Therefore declines in BCS during lactation would be normal.

TABLE 22. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY AGE

	Body condition score	
Age, yr	LSM	SE
3	4.09^a	.03
4	4.19^b	.02
5 & 6	4.32^c	.01
7 & 8	4.26^d	.02
9 & 10	4.19^b	.02
11 & 12	4.11^a	.02
13 & older	3.89^e	.03

a,b,c,d,e Means that do not have a common superscript differ ($P < .05$).

Similarly, the somewhat lowered BCS in the 3-yr-old cows would be expected to result in lower pregnancy rates than those observed. It is probable that BCS in the 3-yr-old cows declined more after calving than in the older aged cows. The lactating 3-yr-old cows were maintained as separate herds and received extra supplementation and superior quality pastures during the calving and breeding periods. Forage quality provided for the 3-yr-olds during the subsequent summer lactational period was much lower than that provided to them during the calving and breeding periods, and was similar to that provided to older cows. Also the typical 3-yr-old cow would have nutritional demands for growth and would have a somewhat smaller digestive capacity relative to weight than at maturity. Further, a reduction in grazing capacity might have been expected in the 3-yr-old cows due to the lose of deciduous teeth. Hence, a greater decline in BCS after calving in the 3-yr-old cows than in the 5 through 8 yr age groups would not be unusual.

Although the breed type x cow age interaction had a highly significant effect on BCS (Table 20), there appeared to be no consistent pattern to this effect. In general, however, BCS was lower in the 13 yr and older age group than in the 4 through 12-yr-old age groups regardless of breed type (Table 23). This did not follow the same trend as pregnancy rates which in general, were relatively constant in the Brangus and Braford breed types regardless of age but declined with increased age in the Brahman and Charbray breed types

(Table 15). Previously discussed explanations for this breed type related differential response include; 1) lower percentage Brahman breeding in the older Charbray breed type cows resulting in less heterosis, 2) expression of the inherent tendency towards infertility in the Brahman breed at older and younger ages, and 3) lower levels of heterozygosity in the Brahman breed type cows resulting in decreased heterosis for longevity.

TABLE 23. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY BREED TYPE AND AGE

	Breed type							
	Brangus		Braford		Charbray		Brahman	
Age, yr	LSM	SE	LSM	SE	LSM	SE	LSM	SE
3	3.9	.04	4.5	.03	4.4	.09	3.6	.08
4	4.1	.08	4.2	.06	4.1	.08	4.3	.09
5 & 6	4.2	.03	4.2	.02	4.6	.05	4.2	.04
7 & 8	4.0	.03	4.1	.02	4.6	.05	4.2	.05
9 & 10	4.0	.04	4.1	.03	4.4	.07	4.3	.05
11 & 12	3.8	.05	3.9	.04	4.5	.09	4.2	.06
13 & older	3.5	.06	3.8	.06	4.3	.01	4.0	.09

Although management unit had a significant effect on BCS (Table 20) and BCS ranged from 4.5 for unit 2 to 3.7 for unit 3 (Table 24), there appeared to be no consistent relationship between pregnancy rate among management unit and BCS at 6 to 10 mo postpartum (Table 11).

TABLE 24. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY MANAGEMENT UNIT RANKED BY BODY CONDITION SCORE

		Body condition score	
Management unit	Pregnancy Rate (%)	LSM	SE
2	79.1	4.47^{a}	.03
6	72.3	4.41^{b}	.02
5	78.0	4.31^{c}	.02
4	82.0	4.26^{cd}	.02
16	65.8	4.23^{de}	.03
12	79.4	4.16^{e}	.03
8	85.4	4.02^{f}	.02
9	73.4	4.00^{fg}	.04
11	74.9	3.92^{g}	.03
3	82.6	3.70^{h}	.03

a,b,c,d,e,f,g,h Means that do not have a common superscript differ ($P < .05$).

PHASE 2
EFFECTS OF PREVIOUS PREGNANCY HISTORY, HAIR LENGTH AND COAT COLOR ON PREGNANCY RATE

Materials and Methods

Data on additional traits, with the potential to explain some of the sources of variation in pregnancy rate, were collected from a subset of the cows included in Phase 1. The additional traits were previous pregnancy history, hair length, and coat color. Data for these traits were collected from at least one herd on each management unit simultaneously with collection of Phase 1 data.

Previous Pregnancy History

Since 1981, cows were culled based on pregnancy status and age. All non-pregnant cows over 8 yr of age were culled and all other non-pregnant cows were fire branded with a bar (-) on the hip. Any such bar-branded cow not pregnant at any subsequent annual pregnancy testing in the fall or not lactating during any subsequent spring was culled. Therefore, a cow without a bar-brand had been nursing a calf in each of the three previous years and a cow with a bar-brand had been non-lactating in one of the three previous years. Each cow was assigned a previous pregnancy history code of 1 (bar-brand) or 0 (no bar-brand). Tables 25, 26, and 27 show the distribution

TABLE 25. NUMBER OF COWS BY AGE AND PREGNANCY HISTORY

	Pregnancy history[a]		
Age, yr	No bar brand	Bar brand	Total number
3	241 (99.6)[b]	1 (.4)	242 (5.9)[c]
4	287 (99.3)	2 (.7)	289 (7.1)
5	481 (77.6)	139 (22.4)	620 (15.2)
6	155 (58.5)	110 (41.5)	265 (6.5)
7	228 (58.2)	164 (41.8)	392 (9.6)
8	362 (66.1)	186 (33.9)	548 (13.5)
9	315 (64.2)	176 (35.8)	491 (12.1)
10	283 (70.1)	121 (29.9)	404 (9.9)
11	219 (76.8)	66 (23.2)	285 (7.0)
12	148 (68.5)	68 (31.5)	216 (5.3)
13	103 (83.1)	21 (16.9)	124 (3.1)
>13	171 (87.7)	24 (12.3)	195 (4.8)
Total number	2,993 (73.5)[d]	1,078 (26.5)	4,071

[a] Bar brand cows either were not pregnant or had lost a calf during one of the three previous calving seasons. No bar brand cows had weaned a calf in each of the three seasons.

[b] Numbers in parentheses indicate frequency percentage by pregnancy history of that age.

[c] Numbers in parentheses indicate percentage of total cows which were that age.

[d] Numbers in parentheses indicate percentage of cows with that pregnancy history.

TABLE 26. NUMBER OF COWS BY PREGNANCY HISTORY AND BODY CONDITION SCORE

Pregnancy history[a]	Body condition score 3	4	5	Total number
Bar brand	170 (15.3)[b]	800 (72.0)	141 (12.7)	1,111 (26.5)[c]
No bar brand	496 (16.1)	2,214 (71.7)	378 (12.2)	3,088 (73.5)
Total number	666 (15.9)[d]	3,014 (71.8)	519 (12.4)	4,199

[a] Bar brand cows either were not pregnant or had lost a calf during one of three previous calving seasons. No bar brand had weaned a calf in each of the three seasons.

[b] Numbers in parentheses indicate the frequency percentage by body condition score of animals with that pregnancy history.

[c] Numbers in parentheses indicate percentage of cows with that pregnancy history.

[d] Numbers in parentheses indicate percentage of total cows with that body condition score.

of cows included in this study by pregnancy history and cow age, BCS and breed type respectively.

TABLE 27. NUMBER OF COWS BY PREGNANCY HISTORY AND BREED TYPE

Pregnancy history[a]	Breed type		Total number
	Brangus	Braford	
Bar brand	665 (59.9)[b]	446 (40.1)	1,111 (26.5)[c]
No bar brand	1,682 (54.5)	1,406 (45.5)	3,088 (73.5)
Total number	2,347 (55.9)[d]	1,852 (44.1)	4,199

a Bar brand cows either were not pregnant or had lost a calf during one of three previous calving seasons. No bar brand had weaned a calf in each of the three seasons.

b Numbers in parentheses indicate the frequency percentage by breed type with that pregnancy history.

c Numbers in parentheses indicate percentage of cows with that pregnancy history.

d Numbers in parentheses indicate percentage of total cows with that breed type.

Hair Length Score

A hair length score of short, medium or long was assigned by one individual to each cow at the fall working in October and November. While these scores were subjectively determined, a score of short approximated a hair length less than 15 mm, a score of medium approximated a hair length of 16 to 30 mm, and a score of long approximated a hair length greater than 30 mm. Since all Brahman breed type cows were assigned a hair length score of short, they were deleted from these analyses. Tables 28 and 29 show the distribution of the cows included in this study by hair length and breed type and BCS respectively.

TABLE 28. NUMBER OF COWS BY HAIR LENGTH AND BREED TYPE

Hair length[a]	Breed type		Total number
	Brangus	Braford	
Short	1,907 (57.1)[b]	1,432 (42.9)	3,339 (79.5)[c]
Medium	243 (47.7)	266 (52.3)	509 (12.1)
Long	197 (56.1)	154 (43.9)	351 (8.4)
Total number	2,347 (55.9)	1,852 (44.1)	4,199

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[a] Short hair length equals 15mm or less, medium hair length equals 16 to 30mm, and long hair length equals over 30mm.

[b] Numbers in parentheses indicate the frequency percentage by breed type of animals with that hair length.

[c] Numbers in parentheses indicate the percentage of total cows with that hair length.

[d] Numbers in parentheses indicate percentage of total cows with that breed type.

TABLE 29. NUMBER OF COWS BY HAIR LENGTH AND BODY CONDITION SCORE

Hair Length[a]	Body condition score			Total number
	3	4	5	
Short	386 (11.6)[b]	2,492 (74.6)	461 (13.8)	3,339 (79.5)[c]
Medium	124 (24.4)	334 (65.6)	51 (10.0)	509 (12.0)
Long	156 (44.4)	188 (53.6)	7 (2.0)	351 (8.4)
Total number	666 (15.9)[d]	3,014 (71.8)	519 (12.4)	4,199

[a] Short hair length equals 15mm or less, medium hair length equals 16 to 30mm, and long hair length equals over 30mm.

[b] Numbers in parentheses indicate the frequency percentage by breed type of animals with that hair length.

[c] Numbers in parentheses indicate the percentage of total cows with that hair length.

[d] Numbers in parentheses indicate percentage of total cows with that hair length.

Coat Color

Each cow was classified by coat color based on the predominate color observed in the coat. Since, the Charbray breed type was composed principally of those cows with a white, yellow or light grey coat color and there were no white Braford or Brangus breed type cows, both the Charbray breed type and white coat color were deleted from these analyses. Hence, the coat colors included in these analyses were red and black, and the breed types included were Braford and Brangus. Tables 30, 31 and 32 show the distribution of the cows included in this study by coat color and breed type, BCS and hair length respectively.

TABLE 30. NUMBER OF COWS BY COAT COLOR AND BREED TYPE

Coat color	Breed type		Total number
	Brangus	Braford	
Red	382 (23.1)[a]	1,275 (77.0)	1,657 (39.5)[b]
Black	1,965 (77.3)	577 (22.7)	2,542 (60.5)
Total number	2,347 (55.9)[c]	1,852 (44.1)	4,199

[a] Numbers in parenthesis indicate the frequency percentage by breed type of animals with that coat color.

[b] Numbers in parentheses indicate percentage of cows with that coat color.

[c] Numbers in parentheses indicate percentage of total cows of that breed type.

Statistical Analyses

The data were analyzed by analysis of variance (ANOVA) using the general linear model (Proc GLM) of the Statistical Analysis System (SAS, 1982). In a preliminary analysis, all least-squares means were non-estimable when the mathematical model included the Phase 1 main effects of body condition score (BCS), age of cow, and breed type and the Phase 2 main effects of previous pregnancy history, hair length and coat color plus all possible two-factor interactions. Subsequently, all interactions involving only Phase 1 main effects and all interactions with probabilities exceeding .50 were deleted from the mathematical model. Also, previous pregnancy history did not significantly affect pregnancy rate and was deleted from the model. For analysis cows were grouped into age classifications of 3-yr-olds, 4-yr-olds, 5- through 9-yr-olds, and 10 yr of age and older. The final mathematical model included the main effects of breed type, body condition score (BCS), age of cow, hair length, and coat color plus the interactions of hair length x coat color, breed type x hair length, hair length x BCS, and breed type x coat color. Data from 4,071 cows on which all data were available, were included in the model.

TABLE 31. NUMBER OF COWS BY COAT COLOR AND BODY CONDITION SCORE

Coat color	Body condition score			Total number
	3	4	5	
Red	216 (13.0)[a]	1,189 (71.8)	252 (15.2)	1,657 (39.5)[b]
Black	450 (17.7)	1,825 (71.8)	267 (10.5)	2,542 (60.5)
Total number	666 (15.9)[c]	3,014 (71.8)	519 (12.4)	4,199

a Numbers in parentheses indicate frequency percentage by BCS of animals with that coat color.

b Numbers in parentheses indicate percentage of total cows with that coat color.

d Numbers in parentheses indicate percentage of total cows with that BCS.

Within each BCS, a separate ANOVA was calculated with pregnancy rate as the dependent variable and breed type, age of cow, hair length, coat color and the interactions of hair length x coat color, breed type x hair length, and breed type x coat color included as independent variables. An additional ANOVA was calculated with BCS as the dependent variable and breed type, age of cow, hair length, coat color, and the interactions of hair length x coat color, breed type x hair length, and breed type x coat color as independent variables.

Least-squares means were compared using T tests provided by the PDIFF option of Proc GLM.

TABLE 32. NUMBER OF COWS BY COAT COLOR AND HAIR LENGTH

Coat color	Hair length			Total number
	Short	Medium	Long	
Red	1,314 (79.3)[a]	222 (13.4)	121 (7.3)	1,657 (39.5)[b]
Black	2,025 (79.7)	287 (11.3)	230 (9.1)	2,542 (60.5)
Total number	3,339 (79.5)[c]	509 (12.1)	351 (8.4)	4,199

a Numbers in parentheses indicate frequency percentage by hair length of animals with that coat color.

b Numbers in parentheses indicate percentage of total cows with that coat color.

c Numbers in parentheses indicate percentage of total cows with that hair length.

Results and Discussion

Pregnancy Rate Across Body Condition Score

The mean pregnancy rate for all cows (n=4,071) was 72.1%. When body condition score (BCS) was included in the model, pregnancy rate was significantly affected by BCS, breed type and the interactions of breed type x hair length and breed type x coat color (Table 33). When BCS was excluded from the model, pregnancy rate was affected by breed type, cow age, hair length and the interaction of breed type x coat color (Table 34). The interactions of breed type x hair length and hair length x coat color approached significance. The fact that age of cow and hair length were not significant when BCS was included in the model, but were when BCS was excluded, would suggest that BCS accounted for much of the variation in pregnancy rate attributable to these factors.

In a preliminary analysis, the pregnancy rate for bar-branded lactating cows (i.e., cows that had failed to wean a calf in one of the three previous calving season but were presently nursing a calf) was not significantly different from the pregnancy rate for non-bar-branded lactating cows. Also, none of the interactions involving previous pregnancy history were significant. Hence, previous pregnancy history and all interactions involving previous pregnancy history were deleted from the analysis. The failure in the present study of previous pregnancy history to affect subsequent reproductive levels is in agreement with the report of Turman et al. (1963)

who found that most nonpregnant cows subsequently calved annually through 10 yr of age.

TABLE 33. ANALYSIS OF VARIANCE FOR FACTORS AFFECTING PREGNANCY RATE (BCS INCLUDED)

Source	df	Mean squares	F	P
Body condition score (BCS)	2	21.67	150.66	.0001
Breed type	1	1.32	9.14	.0025
Cow age	3	.09	.60	.6147
Coat color	1	.24	1.66	.1981
Hair length	2	.07	.68	.5083
Breed type x hair length	2	.52	3.59	.0065
BCS x hair length	4	.04	.32	.0275
Hair length x coat color	2	.22	1.43	.2389
Breed type x coat color	1	3.15	21.93	.0001
Error	4052	.14		

The BCS accounted for large differences (P <. 0001) in pregnancy rate (Table 33). Pregnancy rates were 43.7%, 78.7% and 93.9% for BCS 3, 4, and 5 cows respectively, with significant increases in pregnancy rate with each unit increase in BCS (Table 35). These pregnancy rates for different BCS are, in general, comparable to those obtained in Phase 1 (Table 10) and very similar to those reported in other studies involving pregnancy rate and BCS (Richards et al., 1986; Selk et al., 1988).

The failure of age of cow to significantly impact pregnancy rate when BCS was included in the model (Table 33) is in contrast to the results obtained in Phase 1 (Table 12), where significant differences were observed. It should be noted, however, that grouping of cows by age for purposes of analysis was different in the two phases. In the present study, the data were analyzed using age groups of 3-yr-olds, 4-yr-olds, 5- to 9-yr-olds, and 10 yr of age and older. In contrast, the age groups in Phase 1 consisted of 3-yr-olds, 4-yr-olds, 5- and 6-yr-olds, 7- and 8-yr-olds, 9- and 10-yr-olds, 11- and 12-yr-olds, and cows 13-yr-old and older. The use of larger age groups in the present study was done to eliminate empty subcells in some interactions involving age.

TABLE 34. ANALYSIS OF VARIANCE FOR FACTORS AFFECTING PREGNANCY RATE (BCS EXCLUDED)

Source	df	Mean squares	F	P
Breed type	1	.86	5.34	.0209
Cow age	3	1.21	7.50	.0001
Coat color	1	.19	1.17	.2797
Hair length	2	5.66	34.44	.0001
Breed type x hair length	2	.45	2.75	.0639
Hair length x coat color	2	.42	2.61	.0740
Breed type x coat color	1	2.10	13.00	.0003
Error	4058	.16		

When BCS was deleted from the model, age of cow became a highly significant source of variation for pregnancy rate (Table 34). In this model, pregnancy rates were about 73% for all age groups except the 10 yr and older age group which had a pregnancy rate of 66.4% (Table 35). This is in agreement with the reports of Lindley et al. (1958), Reynolds (1960), and Peacock et al. (1976), who reported lower reproductive performance in older cows. The fact that deletion of BCS from the model resulted in age of cow becoming a significant source of variation for pregnancy rate would suggest that BCS accounted for most of the variation in pregnancy rate resulting from the effects of cow age, probably because older cows had lower BCS.

TABLE 35. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE BY BODY CONDITION SCORE, AGE OF COW, BREED TYPE, AND HAIR LENGTH

Source	Pregnancy rate (%)	
	LSM	SE
Body condition score		
3	43.7[a]	1.9
4	78.7[b]	1.4
5	93.9[c]	5.6
Age, yr		
3	72.6[d]	2.7
4	72.4[d]	2.6
5 through 9	73.2[d]	1.2
10 and older	66.4[e]	1.5
Breed type		
Brangus	68.4[f]	1.8
Braford	73.9[g]	1.7
Hair length		
Short	80.1[a]	1.1
Medium	72.3[b]	2.0
Long	61.9[c]	2.4

[a,b,c] Means within body condition score and within hair length that do not have a common superscript differ ($P < .001$).

[d,e] Means within age groups that do not have a common superscript differ ($P < .0001$).

[f,g] Means within breed type that do not have a common superscript differ ($P < .05$).

In contrast to Phase 1, breed type significantly influenced pregnancy rate in both models (Tables 33 and 34). It should be noted that the present study included only the Brangus and Braford breed types, whereas Phase 1, also included the Charbray and Brahman breed types. In Phase 1, no difference existed in the pregnancy rates between the Brangus and Braford breed types. In contrast, in the model of this study excluding BCS, pregnancy rates were 64.4% and 73.9% for the Brangus and Braford breed types respectively (Table 35). No explanation for this discrepancy is readily apparent.

While hair length did not result in significant differences in pregnancy rates when BCS was included in the model (Table 33), large differences ($P < .0001$) in pregnancy rate due to varying hair length were observed when BCS was deleted from the model (Table 33). This variation in response when BCS was excluded from the model would suggest that a relationship existed between BCS and hair length. Hair length can be influenced by a number of environmental as well as genetic factors (Turner and Schleger, 1960). It is difficult to ascertain in this study whether genetically determined longer hair resulted in higher internal temperatures, poorer performance and consequently lower BCS, or whether disease, parasites or some other environmental factors simultaneously influenced both hair length and BCS. Turner and Schleger (1960) reported the heritability and repeatability of hair length under semi-tropical conditions to be .63 and .60 respectively. Bianca (1959) and Turner (1962) reported better performance in sub-tropical conditions during summer months in long haired cattle whose coat had been clipped than in those left unclipped. These reports would suggest that genetics plays a role in determining hair length under semi-tropical conditions and that genetically dictated longer hair might result in decreased performance. Mean pregnancy rates were 80.1%, 72.3%, and 61.9% in cows with short, medium, and long hair lengths respectively, when BCS was excluded from the model (Table 35).

The breed type x hair length interaction approached significance (Table 34) in the model excluding BCS. This interaction was caused by a significantly lower pregnancy rate for the Brangus type cows with long hair than for the Braford type cows with long hair (Table 36). Pregnancy rates within the Brangus breed type declined significantly with increasing hair length and were 80.2, 69.1, and 56.0% for the short, medium, and long hair lengths respectively. Within the Braford breed type, pregnancy rates for cows with long and medium hair length were 67.7% and 74.0% respectively and were lower than the 80.0% observed for cows with short hair.

Finch et al. (1984) reported that no differences existed in performance (gains) due to coat color between Brahman and Brahman cross steers with light (white or light red) or dark red coat color. These results are consistent with the failure, in the present study, of coat color (Tables 33 and 34) to significantly affect pregnancy rate, since the animals from

TABLE 36. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE BY BREED TYPE AND HAIR LENGTH

	Breed type			
	Brangus		Braford	
Hair length	LSM	SE	LSM	SE
Short	80.2^a	1.3	80.0^a	1.4
Medium	69.1^b	3.0	74.0^b	2.8
Long	56.0^c	3.7	67.7^b	3.5

a,b,c Means that do not have a common superscript differ ($P < .05$).

which the data were collected were of Brahman x *Bos taurus* origin.

In both models, a significant breed type x coat color interaction effect on pregnancy rate was observed (Tables 33 and 34). In the model excluding BCS, Brangus type cows with a red coat color had lower pregnancy rates than Brangus type cows with a black coat color and Braford type cows regardless of coat color (Table 37). Breed type classifications were based on phenotype since the breed origins of the parents were uncertain. While the Brangus type cows with a black coat color almost certainly contained Angus and Brahman breeding, the parentage of the Brangus type cows with a red coat color was less certain and may have included Red Brahman Santa Gertrudis and (or) Hereford as well as Angus breeding. Consequently, comparisons between the Brangus breed type cows with different coat color have limited application.

TABLE 37. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE BY BREED TYPE AND COAT COLOR

	Breed type			
	Brangus		Braford	
Color	LSM	SE	LSM	SE
Red	64.3^a	2.9	75.4^b	1.9
Black	72.5^b	1.6	72.4^b	2.4

a,b Means that do not have a common superscript differ ($P < .05$).

Pregnancy Rate Within Body Condition Score

As in Phase 1, body condition score (BCS) accounted for a significant portion of the variation in pregnancy rate; therefore, the data were analyzed to determine the effect, within each BCS, of the other factors on pregnancy rate (Table 38). The pregnancy rate of BCS 3 cows was affected by breed type and the breed type x coat color interaction. None of the variables analyzed had a significant effect on pregnancy rate in BCS 5 cows. Pregnancy rate in BCS 4 cows was affected (P < .02) by hair length, and the interactions between hair length x coat color and breed type x coat color.

TABLE 38. ANALYSIS OF VARIANCE PROBABILITY VALUES FOR FACTORS AFFECTING PREGNANCY RATE WITHIN BODY CONDITION SCORE

	Body condition score		
Source	3	4	5
Breed type	.02	.09	.52
Cow age	.43	.09	.69
Hair length	.96	.02	.61
Coat color	.37	.29	.06
Hair length x coat color	.22	.02	.31
Breed type x hair length	.73	.15	.82
Breed type x coat color	.02	.0001	.76

In BCS 3 cows, the 30.9% pregnancy rate observed for the Brangus breed type cows was different (P < .02) than the 46.0% observed for the Braford breed type (Table 39). The Brangus breed type cows with red coat color had lower (P < .008) pregnancy rates (20.5%) than the Braford breed type cows with red coat color (50.5%) and tended (P < .09) to be lower than the 41.4% and 41.6% observed in the black coated Brangus and

Braford breed type cows respectively (Table 40). No readily apparent explanation exists for these differences.

TABLE 39. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 3 COWS BY BREED TYPE

	Pregnancy rate (%)	
Breed type	LSM	SE
Brangus	30.9^a	6.1
Braford	46.0^b	4.8

a,b Means that do not have a common superscript differ ($P < .05$).

In BCS 4 cows, the failure of breed type to affect significantly the pregnancy rate (Table 38) seemingly is in contrast to Phase 1 where breeds type had a highly significant effect on pregnancy rate in BCS 4 cows (Table 16). It should be noted, however, that the present study included only the Brangus and Braford breed types, whereas Phase 1 included Brahman and Charbray as well as Braford and Brangus breed types. In Phase 1, no significant difference existed in pregnancy rate between the Brangus and Braford breed type (Table 17). Hence, when comparing the results obtained for the two breed types included in both studies, the results of the two studies were similar.

In Phase 1, age of cow had a highly significant effect on pregnancy rate of BCS 4 cows (Table 16), while age of cow in the present study only tended ($P < .09$) to affect pregnancy rate (Table 38). It should be noted, however, that age grouping of the cows for analysis purposes were different in the two studies. Thus comparisons between pregnancy rates observed in the two phases due to age of cow are not possible.

TABLE 40. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 3 COWS BY BREED TYPE AND COLOR

	Breed type			
	Brangus		Braford	
Color	LSM	SE	LSM	SE
Red	20.5^{a}	10.7	50.5^{b}	4.9
Black	41.5^{ab}	4.9	41.6^{ab}	6.5

a,b Means that do not have a common superscript differ ($P < .005$).

Hair length had a significant effect on pregnancy rate in BCS 4 cows (Tables 38 and 41). The BCS 4 cows with short hair length had a pregnancy rate of 81.6%, which was different ($P < .001$) from the pregnancy rates of 76.5% and 76.2% observed in the BCS 4 cows with medium and long hair length respectively. Turner (1982) reported that increases in body temperatures resulted in a decrease in fertility in both *Bos taurus* and *Bos indicus x Bos taurus cows*. Finch (1986) reported that in the tropics, wooly, deep hair coats resulted in increased body temperatures due to the insulating effect of the coat which reduced the ability to transfer body heat to the surrounding environment. Bianca (1959) and Turner (1962) reported lower body temperatures and higher gains during the summer months in calves whose coats were clipped. Thus, the decline in pregnancy rate in BCS 4 cows with long and medium hair length might have been due to higher body temperatures caused by lower ability to lose body heat.

TABLE 41. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 4 COWS BY HAIR LENGTH

	Pregnancy rate (%)	
Hair length	LSM	SE
Short	81.6^a	1.1
Medium	76.5^b	2.2
Long	76.2^b	3.0

a,b Means that do not have a common superscript differ ($P < .03$).

There were no significant differences in pregnancy rate due to coat color in cows with short or long hair lengths (Table 42); however, cows with medium hair length and red coat color had a pregnancy rate of 70.1% which was lower ($P < .006$) than the pregnancy rate of 82.9% observed in cows with medium hair length and black coat color. This resulted in a significant hair length x coat color interaction (Table 38). No apparent explanation exists for these results.

As in the general analysis across all BCS, a significant breed type x coat color interaction effect on pregnancy rate was observed in the BCS 4 cows (Table 38). The Brangus type cows with a red coat color had a lower pregnancy rate than Brangus type cows with a black coat color and Braford type cows with a red coat color (Table 43). There is no readily apparent explanation for the lower performance of BCS 4 Brangus type cows with a red coat color.

TABLE 42. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 4 COWS BY COAT COLOR AND HAIR LENGTH

	Coat color			
	Red		Black	
Hair length	LSM	SE	LSM	SE
Short	81.9[a]	1.5	81.2[a]	1.5
Medium	70.1[b]	3.5	82.9[a]	3.0
Long	77.8[ab]	5.1	74.6[ab]	4.0

a,b Means that do not have a common superscript differ ($P < .05$).

TABLE 43. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PREGNANCY RATE OF BODY CONDITION SCORE 4 COWS BY BREED TYPE AND COLOR

	Breed type			
	Brangus		Braford	
Color	LSM	SE	LSM	SE
Red	70.1^{a}	3.2	81.2^{b}	1.8
Black	83.0^{b}	2.3	78.0^{ab}	2.9

a,b Means that do not have a common superscript differ ($P < .005$).

Body Condition Score

Since BCS accounted for a significant portion of the variation in pregnancy rate, the data were analyzed to determine what effects the other variables had on BCS. Mean BCS was 3.8. BCS was significantly affected by age of cow, hair length, and the interactions between hair length x coat color and breed type x coat color (Table 44).

TABLE 44. ANALYSIS OF VARIANCE FOR FACTORS AFFECTING BODY CONDITION SCORE

Source	df	Mean squares	F	P
Breed type	1	.27	1.04	.3082
Cow age	3	8.26	32.26	.0001
Hair length	2	34.41	134.43	.0001
Coat color	1	.08	.31	.5784
Hair length x coat color	2	.87	3.40	.0333
Breed x hair length	2	.09	.38	.6861
Breed x coat color	1	2.83	11.07	.0009
Error	4058	.26		

The mean BCS for all age groups except the 10 yr of age and older group was 3.9 which was significantly different from the BCS of 3.7 observed for the 10 yr of age and older cows (Table 45). Pregnancy rate in the general analysis across all BCS was not influenced by age of cow (Table 33). However, when BCS was deleted from the general analysis, age of cow significantly impacted pregnancy rate (Table 34). This suggests that most of the impact of age of cow on pregnancy rate was due to differences in BCS. Both the pregnancy rate and BCS were lower for the cows 10 yr of age and older than for the other three age groups (Table 35).

TABLE 45. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY AGE

	Body condition score	
Age, yr	LSM	SE
3	3.9^a	.04
4	3.9^a	.03
5 through 9	3.9^a	.02
10 and older	3.7^b	.02

a,b Means that do not have a common superscript differ (P < .0001).

Hair length had a significant effect on BCS (Table 44). Mean BCS were 4.1, 3.9, and 3.6 for cows with short, medium, and long hair lengths (Table 46). As has been discussed in the general analysis across all BCS, it is difficult to ascertain in this study whether genetically determined longer hair resulted in higher internal temperatures, poorer performance and thus lower BCS or whether environmental factors resulted in poorer performance, lower BCS and the longer hair which sometimes occurs in stressed cattle. The reports of Bianca (1959) and Turner (1962) that long haired calves whose coats had been clipped performed better than those left unclipped, coupled with the reported heritability of .63 for hair length under tropical conditions (Turner and Schleger, 1960) would suggest that genetically determined hair length plays a substantial role in animal performance in *Bos taurus* derivative cattle in the tropics.

TABLE 46. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY HAIR LENGTH

	Body condition Score	
Hair length	LSM	SE
Short	4.1^a	.01
Medium	3.9^b	.03
Long	3.6^c	.03

a,b,c Means that do not have a common superscript differ ($P < .001$).

While the interaction between hair length and coat color was significant (Table 44), the only differences in BCS were observed in cows with short hair length (Table 47). Cows with short hair length and red coat color had a BCS of 4.1 while cows with short hair length and black coat color had a BCS of 4.0. While this difference was significant, the relatively small size of the difference makes it of no biological value.

TABLE 47. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY COAT COLOR AND HAIR LENGTH

	Coat color			
	Red		Black	
Hair length	LSM	SE	LSM	SE
Short	4.1^{a}	.02	4.0^{b}	.02
Medium	3.9^{c}	.04	3.9^{c}	.03
Long	3.6^{d}	.05	3.6^{d}	.04

a,b,c,d Means that do not have a common superscript differ ($P < .05$).

Pregnancy rate was not influenced by the hair length x coat color interaction (Table 34). The breed type x coat color interaction was a significant source of variation for BCS (Table 44), but the differences in BCS were small and of no biological value (Table 48).

TABLE 48. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BODY CONDITION SCORE BY COAT COLOR AND BREED TYPE

	Coat color			
	Red		Black	
Breed type	LSM	SE	LSM	SE
Brangus	3.90^{a}	.04	3.80^{b}	.02
Braford	3.82^{b}	.02	3.85^{ab}	.03

a,b,c Means that do not have a common superscript differ ($P < .05$).

SUMMARY

Data on 21,289 lactating cows, gathered in 1985 at a large central Florida ranch, were analyzed to determine the effects on pregnancy rate of body condition score (BCS), age of cow, management unit, breed type, and all possible two factor interactions. Cows were grouped for analysis into age classifications of 3-yr-olds, 4-yr-olds, 5- and 6-yr-olds, 7- and 8-yr-olds, 9- and 10-yr-olds, 11- and 12-yr-olds, and 13 yr of age and older. Breed types included Brangus, Braford, Charbray, and Brahman. Additional analyses were made to determine the effects of age of cow, management unit, breed type, and all possible two factor interactions on pregnancy rate within each BCS and on BCS.

The mean pregnancy rate was 77.2%. Large differences in pregnancy rates were observed due to variations in BCS. The BCS had the largest effect on pregnancy rate of any variable analyzed and resulted in a 54 percentage point range in pregnancy rate. Pregnancy rates ranged from 43.2% in BCS 3 cows to 76.4% in BCS 4 cows and to 92.7% and 96.9% in BCS 5 and 6 cows.

Age of cow affected pregnancy rate, with pregnancy rates ranging from 81% in the 3-yr-old cows to 72.3% in the 11 and 12 yr age group. Pregnancy rate began to decline at 9 yr, reached the lowest level in the 11 and 12 yr age group, and then tended to increase in the 13 and older age group. The BCS x age of cow interaction had a significant impact on pregnancy rate. Pregnancy rates in BCS 3 and 4 cows declined after the animals were 8 yr of age but remained essentially the same at all ages for BCS 5 and 6 cows. The 3-yr-old BCS 3 cows had a higher pregnancy rate than the other BCS 3 cows.

Breed type did not significantly impact pregnancy rate; however, there was a significant breed type x age of cow interaction. In general, pregnancy rates were relatively constant across age groups in the Brangus and Braford breed types. Brahman type cows tended to have a lower pregnancy rate at younger and older ages than in the 5- through 8-yr-old cows and pregnancy rate in the Charbray breed type declined after 8 yr of age.

Within BCS 4 cows, the Brangus and Braford type cows had pregnancy rates of 81.7% and 79.5% respectively, which were higher than the pregnancy rate of 68.7% in the Brahman type cows. The BCS 4 Charbray type cows had a pregnancy rate of 75.9% which did not differ significantly from any of the other breed types. Within BCS 4 cows, age also affected pregnancy rate. Pregnancy rate was higher in the 5- through 8-yr-old cows than in all older age groups; however, pregnancy rate in the 3-yr-old BCS 4 cows did not differ significantly from pregnancy rate for the other age groups. A significant breed type x age of cow interaction effect on pregnancy rate was also observed in BCS 4 cows. In the BCS 4 Brangus and Braford type cows, pregnancy rates generally persisted at a relatively constant level into the 13 yr of age and older group. A decline in pregnancy rate beginning at age 9 was observed in the Charbray and Brahman breed types. In BCS 4 Brahman type cows, pregnancy rates were also lower in the 3- and 4-yr-olds than in the 5- through 8-yr-olds.

The overall mean BCS for the cows in this study was 4.2, and BCS was significantly affected by breed type, management unit, age of cow and the interactions of management unit x age of cow and breed type x age of cow. Charbray breed type had the highest average BCS (4.4) and the Braford and Brahman had higher average BCS (4.1 and 4.1 respectively) than the Brangus breed type (4.0). Mean BCS peaked in the 5- through 8-yr-old cows at 4.3 and declined consistently with increased or decreased age. The lowest mean BCS observed in any age group was a 3.9 in the cows 13 year of age and older. Management unit had a significant effect on BCS and BCS ranged from 4.5 to 3.7 among the various units. There was no consistent within management unit relationship between BCS and pregnancy rate.

In a 4,071 cow subset, additional data were gathered of previous pregnancy history, hair length, and coat color. Analyses conducted included 1) the effect of all other factors on pregnancy rate, 2) the effect within each BCS of the remaining factors on pregnancy rate, and 3) the effects on BCS of remaining factors. After preliminary analyses, the final mathematical model included the main effects of breed type, BCS, age of cow, hair length, and coat color, plus the interactions of hair length x coat color, breed type x hair length, hair length x BCS, and breed type x coat color. Age groups used for analysis included 3-yr-olds, 4-yr-olds, 5- through 9-yr-olds, and 10 yr of age and older. Breed types included were Brangus and Braford.

Within the subset group, the mean pregnancy rate was 72.1%. Cows which had weaned a calf in each of the three previous calving season did not differ in pregnancy rate from cows which had failed to wean a calf in one of the three previous calving season. The BCS, when included in the subset model, accounted for large differences in pregnancy rate. Mean pregnancy rates were 43.7%, 78.7%, and 93.9% for BCS 3, 4, and 5 cows respectively. Age of cow did not affect pregnancy rate when BCS was included in the model, but was a significant source of variation when BCS was deleted from the model. When BCS was deleted from the model, pregnancy rates were about 73% for all age groups except the 10 yr of age and older group which had a pregnancy rate of 66.4%. Similarly, hair length did not affect pregnancy rate when BCS was included in the model, but became a significant source of variation when BCS was deleted from the model. When BCS was deleted from the model, mean pregnancy rates were 80.1%, 72.3%, and 61.9% for cows with short, medium, and long hair lengths respectively.

Coat color did not affect pregnancy rate; however, there was a significant breed type x coat color interaction. In the model excluding BCS, Brangus type cows with a red coat had lower pregnancy rates than Brangus and Braford type cows with a black coat color and Braford type cows with a red coat color.

Within BCS 3 cows, pregnancy rate was affected by breed type and the breed type x coat color interaction. None of the variables analyzed had a significant effect on pregnancy rate within BCS 5 cows. Within BCS 4 cows, pregnancy rate was affected by hair length, and the interactions of hair length x coat color and breed type x coat color. Within BCS 3 cows, the 30.9% pregnancy rate observed for the Brangus type cows was lower than the 46.0% observed for the Braford type cows. Also the Brangus type cows with red coat color had a lower pregnancy rate (20.5%) than the Brangus type cow with black coat color (50.5%). Pregnancy rates in the Braford cows with red and black coat colors were 41.4% and 41.6% respectively.

Within BCS 4 cows, hair length had a significant effect on pregnancy rate. The BCS 4 cows with short hair length had a pregnancy rate of 81.6% which was higher than the 76.5% and 76.2% observed for cows with medium and long hair length respectively.

While there were no significant differences in pregnancy rates due to coat color, the interaction of coat color x hair length was a significant source of variation. The BCS 4 cows with medium hair length and red coat color had an average pregnancy rate of 70.1% which was lower than the pregnancy rate of 82.9% observed in cows with medium hair length and black coat color.

The interaction between breed type and coat color was also a significant source of variation for pregnancy rate. The BCS 4 Brangus type cows with red coat color had a lower pregnancy rate (70.1%) than the Brangus type cows with black coat color (83.0%) and the Braford type cows with red coat color (81.2%). The 78.0% pregnancy rate observed in BCS 4 Braford type cows with black coat color did not differ statistically from any of the other groups.

Mean BCS for the subset of 4,071 cows was 3.8 and BCS was affected by age of cow, hair length, and the interactions of hair length x coat color and breed type x coat color. The mean BCS for all age groups except the 10 yr of age and older group was 3.9, which was significantly different than the BCS of 3.7 observed for the 10 yr of age and older group. Cows with short, medium and long hair lengths had mean BCS of 4.1, 3.9, and 3.6 respectively.

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BIOGRAPHICAL SKETCH

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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